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Pamphagus sardeus (Herrich-Schaeffer, 1840) - Italy, Sardinia: Orroli, Nuraghe Arrubiu

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The family Pamphagidae. The family Pamphagidae is a relatively small family of grasshoppers belonging to the superfamily Acridoidea. It comprises 96 genera and 561 species and subspecies. They are only found in the Palaearctic and Afrotropical Regions. Only twelve species in the genus *Pamphagus* Thunberg, 1815 are currently known; all the species are squamipterous, with a very robust and stocky appearance. Sexual dimorphism is remarkable, especially the differences in size. Seven species are present in Algeria, the other five species are known to be from Morocco, Tunisia, Libya, Lampedusa, Sardinia and Sicily. *Pamphagus sardeus* (Herrich-Schaeffer, 1840) is a Sardinian endemism, where most records stem from the southern half of the island. It lives in dry natural grasslands and the adults can be found in spring and summer. *Pamphagus marmoratus* Burmeister, 1838 is a very large, green grasshopper. The wings are very short, small flaps sticking out laterally from the pronotum. *Pamphagus marmoratus* is a Sicilian endemism, restricted to the central-western parts of this island. It lives in dry open habitats with shrubs, preferably on calcareous substrate. *Pamphagus ortolaniae* Cusimano et Massa, 1977 can be distinguished from the similar *P. marmoratus* and *P. sardeus* by the smaller size, shape of the pronotum and male genitalia. It lives only in Lampedusa Island. The adults can be found throughout the year in dry natural grasslands, where it can build up big populations.

Marcello Romano. Piazza A. Cataldo 10, 90040 Capaci, Palermo, Italy; e-mail: marcellr@libero.it (photos M. Romano).

Pamphagus marmoratus, Sicily, San Vito Lo Capo (above) and *P. ortolaniae,* Lampedusa Island (below).

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A new species of the genus *Schileykiella* Manganelli, Sparacio et Giusti, 1989 from Sicily (Italy) (Gastropoda Pulmonata Canariellidae)

Roberto Viviano[1*], Arturo Viviano[1], Fabio Liberto[2], Agatino Reitano[3] & Ignazio Sparacio[4]

[1]Via Michele Cipolla 106, 90123 Palermo, Italy; e-mail: roberto.viviano3@outlook.com, vivix945@gmail.com
[2]Via del Giubileo Magno 93, 90015 Cefalù, Italy; e-mail: fabioliberto@yahoo.it
[2]Museo di Storia Naturale di Comiso, via degli Studi 9, 97013 Comiso, Italy; e-mail: tinohawk@yahoo.it.
[4]via Principe di Paternò 3, 90144 Palermo, Italy; e-mail: edizionidanaus@gmail.com
[*]Corresponding author

ABSTRACT *Schileykiella mariarosariae* n. sp. (Gastropoda Pulmonata Canariellidae) is described from Mount Pecoraro, Cinisi (Palermo, Sicily, Italy). The new species is characterized by lenticular shell with keeled whorls and very short hairs, genitalia with long penis, short epiphallus, long flagellum, very flared initial portion of the duct of bursa copulatrix. Additional ecological, biological and taxonomic notes are provided.

KEY WORDS Canariellidae; *Schileykiella*; taxonomy; new species; Mount Pecoraro; Sicily.

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INTRODUCTION

Malacological research carried out in the mountains of Palermo (Sicily, Italy) allowed us to identify a new population of small terrestrial molluscs.

Already from the examination of the shell, it appeared different from the other Sicilian populations, and, the study of the genital morphology, revealed its belonging to a new species of the genus *Schileykiella* Manganelli, Sparacio et Giusti, 1989 (Gastropoda Pulmonata Canariellidae).

This genus includes, at moment, three species from Sicily and Maltese Islands (Manganelli et al., 1989; Giusti et al., 1995; Cianfanelli et al., 2004): *S. parlatoris* (Bivona, 1839) widespread in Sicily and Gozo Island, *S. reinae* (Pfeiffer, 1857) widespread in north-western and central Sicily, and *S. bodoni* Cianfanelli, Manganelli et Giusti, 2004 endemic of Marettimo Island (Aegadian Archipelago, North Western Sicily).

In the present work, this new species of *Schileykiella* is described.

MATERIAL AND METHODS

Empty shells and live specimens were collected in the field by eye-sight, on the ground and under stones and various debris, at daylight, but also sifting debris samples in laboratory. The study area was examined from a geological and botanical point of view. The specimens were studied as regards size, colour, external morphology and genitalia. The measurements were made with digital gauge and micrometer. The shells have been immersed for less than two minutes in a solution with 60% of water (H_2O), and 40% of NaClO, and sub-

sequently clean with water and a flattipped and hard bristles paintbrush. Some specimens were fixed in 80% ethanol and reproductive apparatus was extracted by means of scalpel, scissors and needles. The samples were observed through the Optika stereomicroscope and Scanning Electron Microscope HV: 20.00 kV at the Department of Geological Sciences of the University of Catania. Illustrations of genitalia were sketched using a camera lucida. The photos were taken with a Nikon D3100 18-55 camera, with a Canon EOS 100D camera. A single specimen was also examined uncoated under a Tescan Vega 2 LMU Scanning Electron Microscope in Low Vacuum modality to investigate shell micromorphology. All images were acquired at the Department of Biological, Geological and Environmental Sciences (University of Catania).

To study the biological cycle, two adult specimens were bred in the laboratory, from December 2017 to December 2018, in a small terrarium (13 cm long x 9 cm wide x 4 cm high) with a layer of soil 15 mm deep, small calcareous rocks and organic debris.

The toponyms are reported following the "Geoportale Nazionale, Map IGM 1: 25000". Each sampling site is denominated in the original language (Italian).

Taxonomical references are based on the checklist of land and freshwater Gastropoda of Europe (Bank & Neubert, 2018) and other cited papers. The average temperatures and humidity concern the months of January and February 2018 (https://www.ilmeteo.it/portale/archivio-meteo). The voucher specimens are deposited in the following Museums and private collections: CG (S. Giglio collection, Cefalù, Italy); CL (F. Liberto collection, Cefalù, Italy); MCZR (Museo Civico di Zoologia collection, Roma, Italy); MZP (Museo di Zoologia "Pietro Doderlein" collection, Palermo, Italy); CR (A. Reitano collection, Catania, Italy); CS (I. Sparacio collection, Palermo, Italy); CV (Viviano collection, Palermo, Italy).

Unless otherwise stated, the collector of the molluscs in the field is the owner of the collection where the specimens are preseved.

ABBREVIATIONS AND ACRONYMS. A: atrium; BC: bursa copulatrix; DBC: duct of bursa copulatrix; E: epiphallus; F: flagellum; FO: free oviduct; LDL: left dorsal lobe; LLL: left lateral lobe; P: penis; PR: penial retractor; RDL: right dorsal lobe; RLL: right lateral lobe; SL: subpneumostomal lobe; UOS: uterine ovispermiduct; V: vagina; VD: vas deferens; ex/x: specimen/s; T: Temperature.

RESULTS

Systematics

Phylum MOLLUSCA Cuvier, 1795
Classis GASTROPODA Cuvier, 1795
Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo STYLOMMATOPHORA A. Schmidt, 1855
Subordo HELICINA Rafinesque, 1815
Infraordo HELICOIDEI Rafinesque, 1815
Superfamilia HELICOIDEA Rafinesque, 1815
Familia CANARIELLIDAE Schileyko, 1991
Genus *Schileykiella* Manganelli, Sparacio et Giusti, 1989

Schileykiella mariarosariae n. sp. (Figs. 3–18)

TYPE LOCALITY. North side of Mount Pecoraro, Cinisi (Palermo, Sicily, Italy).

TYPE MATERIAL. Holotype (Figs. 3–6): North side of Mount Pecoraro, Cinisi, above Portella Scaletti (Palermo, Sicily, Italy), 38°10'214"N 13°07'26"E, 230 m, legit R. Viviano & A. Viviano, 10.II.2019, 1 ex (MCZR). Paratypes: above Portella Scaletti, 230 m, 24.XII.2017, 4 shells, 2 exx (CV0078); idem, 230-250 m, 02.III.2018, 14 shells (CV0100); idem, leg. R. Viviano (Figs. 9–12) (CR); garigue above the rock spur, 38°10'13.7"N 13°07'26"E, 340–360 m, 02.III.2018, 9 shells (CV0121); above Portella Scaletti, 275 m, 02.III.2018, 1 shell (CV0129); NE side of Pizzo Angelelli, 38°10'09"N 13°07'26"E, 420 m, 02.III.2018, 2 shells (CV0145); garigue above the rock spur, 360 m, legit R. Viviano & A. Viviano, 05.XI.2018, 11 shells (CV0166); idem, 340 m, 05.XI.2018, 3 shells (CV0168); Portella Scaletti, 38°10'25"N; 13°07'25"E, 195 m, 6.I.2018, 1 shell (CL17739); above Portella Scaletti, 292 m, 30.XII.2018, 3 exx, 29 shells (CL18066–18097, Fig. 7); idem, 30.XII.2018, 30 shells (CG); idem, 230 m, legit R. Viviano & A. Viviano, 10.II.2019, 7 shells, 2 exx (CV0176); idem, 230 m, legit R. Vi-

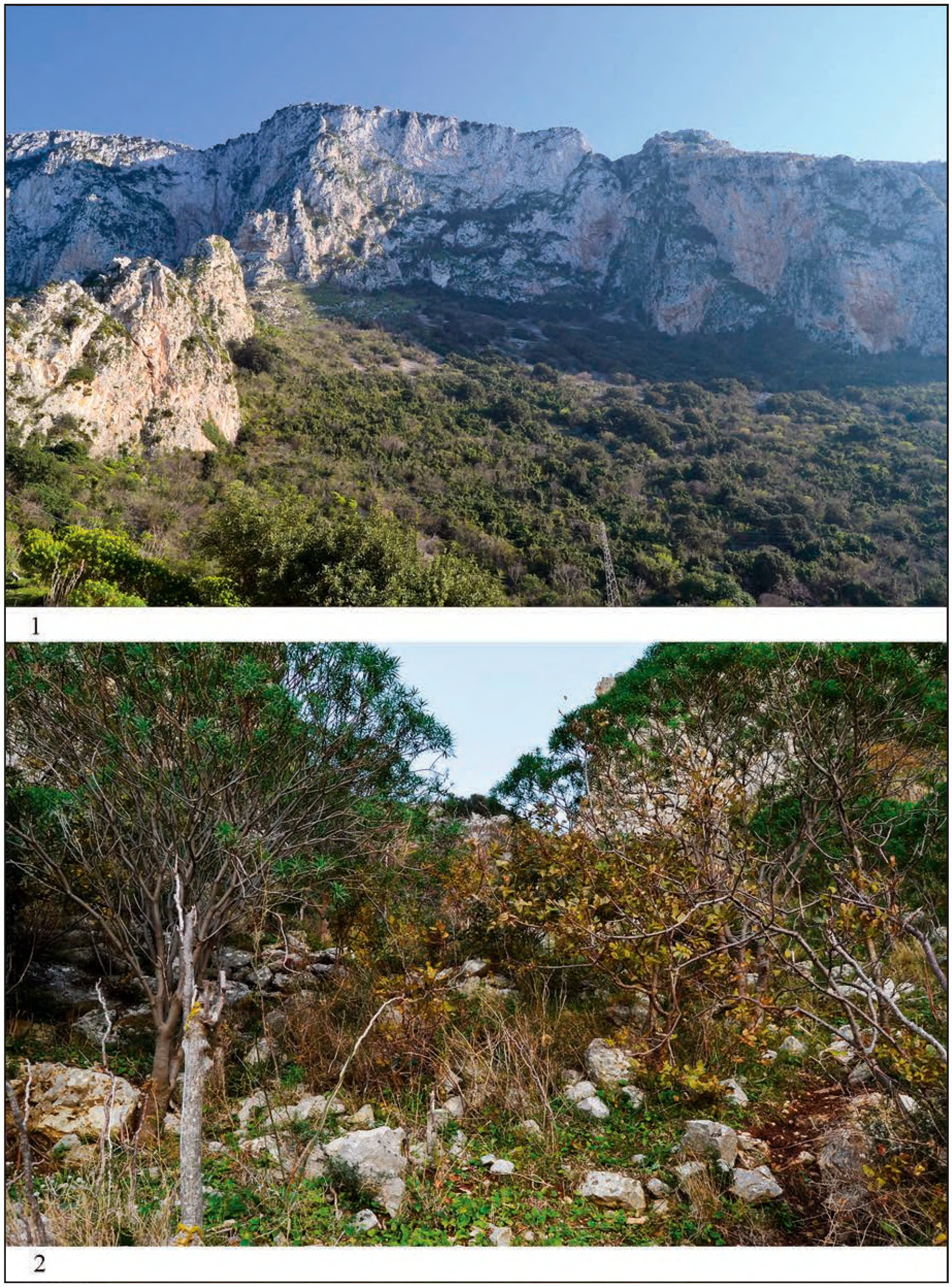

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Figure 1. Northern side of Monte Pecoraro and Portella Scaletti (north-western Sicily, Italy).
Figure 2. Study area: detritus slopes, at the base of limestone walls, with Mediterranean maquis.

viano & A. Viviano, 10.II.2019, 1 shell (MZP); NE side of Pizzo Angelelli, 38°10'14"N 13°07'19"E, 275–300 m, 10.II.2019, 1 shell (CV0177); idem, 240 m, 23.III.2019, 6 shells (CR); above Portella Scaletti, 230 m, 02.I.2018, 2 shells (CS5045/2); idem, 245 m, 24.III.2019, 9 shells (CS5046/9).

DESCRIPTION OF HOLOTYPE. Shell dextral, small (diameter 9 mm, height 2.7 mm, umbilicus diameter 3.5 mm, aperture diameter 3.8 mm, aperture height 3 mm), lenticular, scalariform in frontal view, little raised above and convex below, yellowish in colour, opaque, with microscopic hairs; spire formated by 4.5 increasing whorls separated by deep sutures; the last two whorls with keel on external margin (0.7 wide on the last whorl); umbilicus deep and wide 1/3 of shell maximum diameter; aperture oblique, strongly keeled at its external margin, with slightly inclined upper edge and convex lower edge; peristome not thickened, little reflexed at its columellar margin; the protoconch measure 1.5 mm; suture slightly furrowed; surface with longitudinal furrows and some growth lines; periostracal surface of teleoconch, with impressions of hair roots and scarce and irregular hairs from 50 to 130–150 μm in length; microsculpture consisting of very fine grooves that follow the spiral (Figs. 9–12).

Body. Animal yellowish-white with brownish-black spots, not particularly extensive; the internal viscera reddish-brown. Mantle border (Fig. 7) sub-oval in contour, very protruding at left upper vertex in corrispondence of the shell keel, with five lobes: right and left dorsal lobes bordering upper margin of small pneumostome; subpneumostomal lobe sub-rectangular; right lateral lobe is very large, triangular, wider at the base; left lateral lobe elongated. Eye tentacles extensible up to 3 mm, tactile tentacles up to 0.8 mm, both contractile, rounded ends, simple pupils; foot extensible up to 6.5–7 mm with yellowish and non partite sole; pneumostome with a diameter of 0.2–0.3 mm with adjacent anal orifice; both orifices are surrounded by a lighter mantle margin.

Genitalia. Female distal genitalia include free oviduct, bursa copulatrix and its duct, and vagina. Vagina very short (1.6 mm) without accessory organs (dart-sac complex, digitiform glands); internal wall of vagina with very thin parallel pleats. Duct of bursa copulatrix long (6 mm) with initial portion very flared; bursa copulatrix rounded-oval; free oviduct long (3.1 mm), slender, sub-cylindrical.

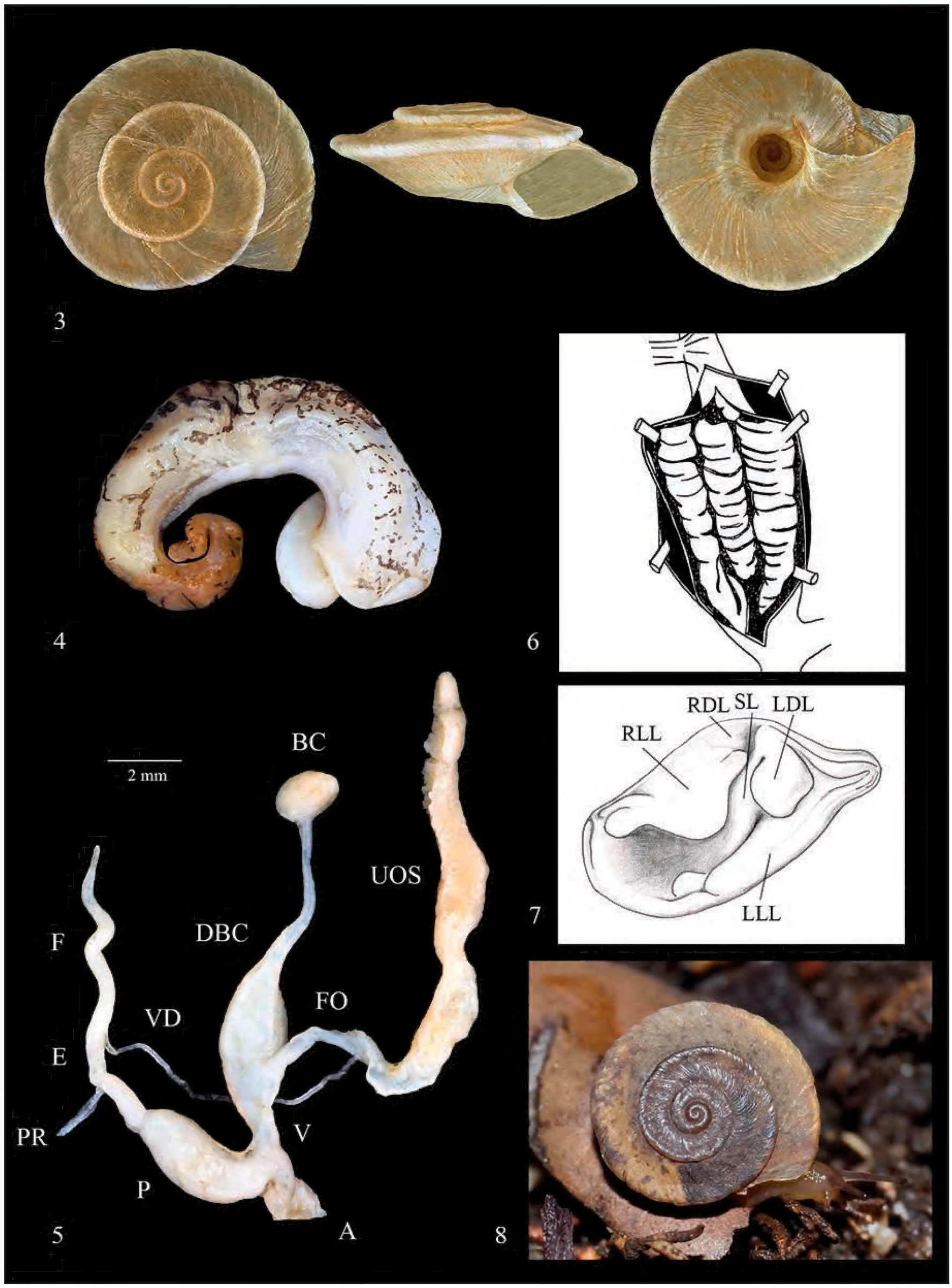
Male genital complex consists of flagellum, epiphallus, and penis. Flagellum long (4.8 mm), thin at the apex and wider at the base where it is equal in calibre to the epiphallus which follows; epiphallus short (2.1 mm), extending from the end of the vas deferent to the point of attachment of the penial retractor muscle; penis (extending from penial retractor muscle to genital atrium) long (4.5 mm), flared and wider at the distal portion and thinned towards the proximal portion, connected to the atrium by a large opening. Internal wall of penis with series of parallel pleats, also interrupted, larger inside distal part of penis; in particular, one large and central swollen folds has the base at the end of the proximal penis and is interrupted distally, and an other lateral swollen fold forms a pillar structure. Penial retractor muscle long and wide, inserted on penial sheath and ending on diaphragm walls. Vas deferens is ribbon-like, partly sub-transparent, not very long, connected to the proximal portion of the free oviduct. Genital atrium wide with slight strangulation on the aperture of the genital complexes.

VARIABILITY. Paratypes: shell with maximum diameter of 9–9.8 mm; maximum height of 2.7–3.6 mm; aperture height of 2.1–2.5 mm, aperture width of 3.7–4.2 mm; umbilicus wide from 1.5 mm to 2.1 mm; keel from 0.5 to 0.8 mm; yellowish in colour, sometimes whitish-brown or whitish, if partially or totally deperiostracated; keel little jagged and undulating in some points, hollow inside, sometimes slightly raised or slightly curved downwards, it has a quicker discoloration. In the second specimen examined anatomically, the internal wall of the penis showed the two main folds that are joined distally. In juvenile specimens, the aperture is flat and with acute angle. Some paratypes have large fractures and holes in the shell caused by natural occurrences.

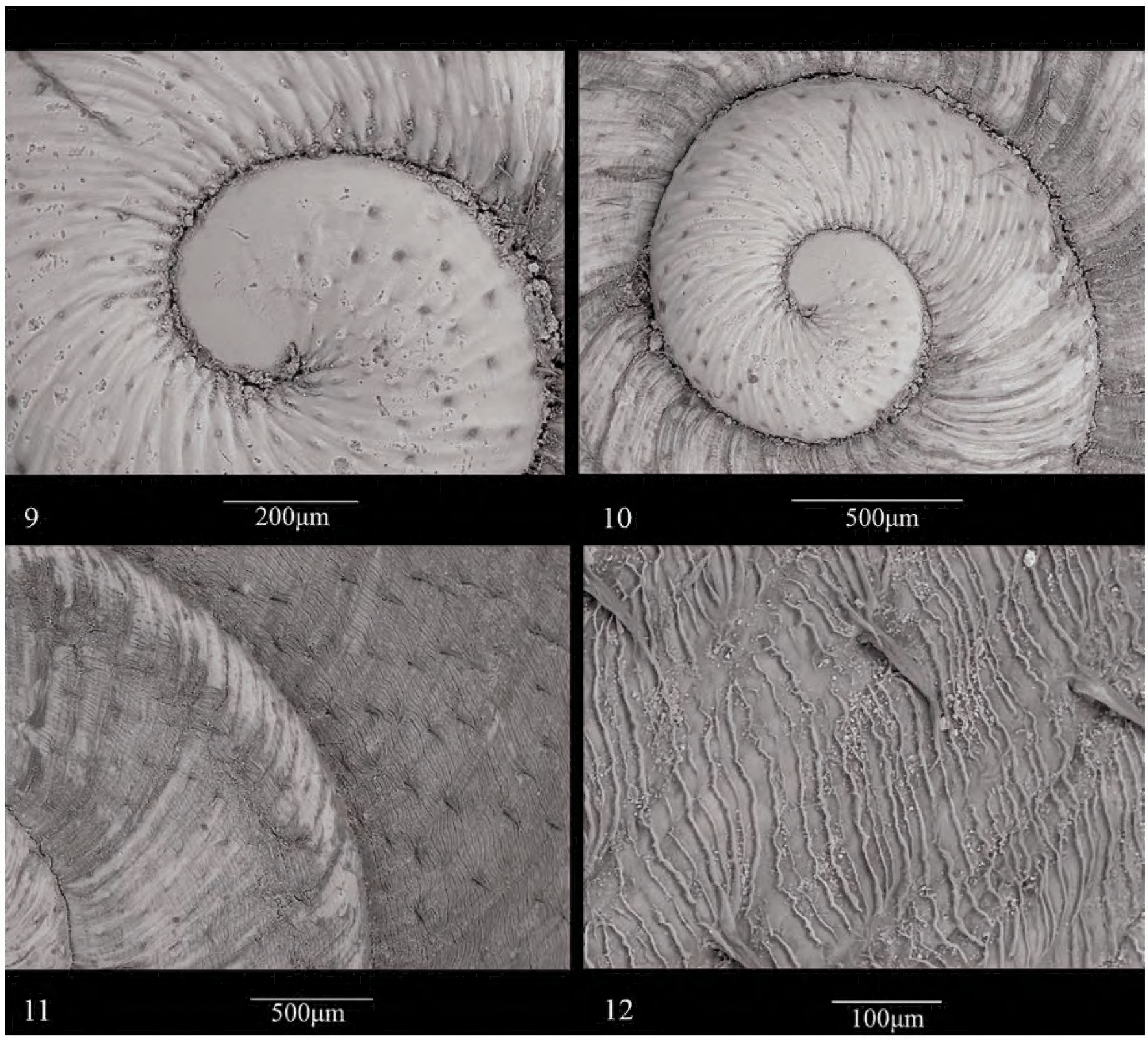
ETYMOLOGY. The new species is dedicated to the dear memory of Viviano's mother (Maria) and to their maternal grandmother (Rosaria) for her dedication to the family: Maria + Rosaria (-ae), used as a noun in apposition.

DISTRIBUTION AND BIOLOGY. This new species is spread in the northern slope of Mount Pecoraro.

Mount Pecoraro falls within Meso-Cenozoic calcareous rocks of the Panormide Units, a carbonate platform constituting the skeleton of the northernmost sector of Palermo Mountains. These are



Figures 3–6. *Schileykiella mariarosariae* n. sp. from Portella Scaletti, Mount Pecoraro (Cinisi, Italy), holotype, diameter 9 mm. Fig. 3: shell. Fig. 4: body. Fig. 5: distal genitalia. Fig. 6: internal wall of penis. Fig. 7: idem, paratype, mantle collar. Fig. 8: idem, paratype, living specimen.



Figures 9–12. Detail of shell microsculpture (Scanning Electron Microscope) of *Schileykiella mariarosariae* n. sp., paratype, from Portella Scaletti, Mount Pecoraro, Sicily, Italy) (explanations in the text).

part of the Sicilian "Fold and Thrust Belt", which, at the boundary between the African and the European plates, links the African Maghrebides to the Calabrian arc subduction complex and to the southern Apennines (Catalano et al., 2013).

This northern side, extended 1.4 km, is bordered to the West by Portella del Trono and to the East by Casa Abbate, while, in the central part, it is cut by the limestone crest of Portella Scaletti. The two principal peaks are Cima Bosco Tagliato and Pizzo Angelelli. They are two vertical limestone walls 700 m high with a steep detritus slope colonised by vegetation which descends from 400 m to 100 m. They are almost always in the shade and, due to the northern exposure, have a more humid microclimate than the neighboring areas.

This mountain also falls into the Mediterranean pluviseasonal oceanic bioclimate (Rivas-Martínez et al., 2008), with lower mesomediterranean thermotype (Bazan et al., 2015). These bioclimatic conditions, however, are buffered and cooled by a daily moisture condensation, often forming a very dense fog, due to the humid sea breeze arising from the Tyrrhenian Sea (Cusimano et al., 2017).

The study area is affected by a zonal vegetation with *Quercus ilex* L. wood on calcareous lithotypes along the slopes characterized by screes and by the sub-mountain belt grassland (Maurici & Manfrè

Scuderi, 2001; Gianguzzi & Papini, 2015). These environments are characterized by Mediterranean maquis with *Euphorbia dendroides* L., *Rhus coriaria* L., *Fraxinus ornus* L., *Phyllirea latifolia* L., *Rhamnus alaternus* L., *Crataegus* sp., *Foeniculum vulgare* L., *Ruta chalepensis* L., *Micromeria graeca* sp. *fruticulosa* (Bertol.) Guinea, *Asparagus acutifolius* L., *Smilax aspera* L., and herbaceous plants such as *Cynodon* sp., *Arisarum vulgare* Targ. Tozz., *Arum italicum* Mill., *Allium* sp., *Medicago* sp., or from grassland on semi-rocky slope with predominance of *Charybdis pancration* (Steinh.) Speta, *Smyrnium olusatrum* L, *Elaeoselinium asclepium* (L.) Bertol, *Asphodelus ramosus* L., *Hyparrhenia hirta* L. and various herbaceous essences (Asteraceae), mixed with a few shrubs such as *Rhus coriaria* L. and *Euphorbia dendroides* L. Other plant species gregariously distributed that can be found on the slope are *Ampelodesmos mauritanicus* (Poir.) Dur. et Schinz and *Ailanthus altissima* (Mill.) Swingle, the latter non-native and invasive.

Schileykiella mariarosariae n. sp. has sciaphilous, sublapidicolous and detriticolous biology; the most numerous samples have been found under accumulations of small and medium-sized stones, separated by interstices where vegetable debris accumulates. Often these clasts are dominated by a large rock, or are located at the base of a low rocky outcrop. This new species prefers ventilated environments, sunny for a few hours a day, characterized by Mediterranean maquis.

In this same habitat, other endemic species have been found: *Cochlostoma paladilhianum* (Saint-Simon, 1869) (Megalomastomatidae), *Hypnophila cylindracea* (Calcara, 1840) (Azecidae), *Cecilioides raphidia sicula* Beckmann et Falkner, 2008 (Ferussaciidae), *Hohenwartiana aradasiana* (Benoit, 1862) (Ferussaciidae), *Siciliaria tiberii scalettensis* Beckmann, 2004 (Clausiliidae), *Vitrea* cf. *contracta* (Westerlund, 1871) (Pristilomatidae), and *S. reinae*.

The biological cycle was observed in laboratory (Palermo) (Figs. 8–14). At the beginning of January with a T of 17° C and a humidity of 59%, one of the two specimens slightly inflates the cephalic region and, partially, also the atrial region, as a sign of pre-courtship; the other specimen seems to ignore this signal. The specimen suitor does not move away from the partner, and is kept for about 30 minutes within a 25–35 mm radius, without obtaining any results. No courtships shared by both partners or matings were observed. Both specimens have laid a group of eggs. The first specimen released a total of 15 eggs, for about 4 hours, at a depth of 12 mm in the soil; the hatches were recorded on 01–02.II.2018 after an incubation period of 22–23 days. The second specimen released a total of 22 eggs, for about 7 hours, at a depth of 10 mm in the soil; the hatches were recorded on days 06–07.II.2018 after an incubation period that lasted 21–22 days. During oviposition, both specimens placed the shell vertically, with the aperture immersed in the soil and the remaining part exposed to the air. No incubation chambers were observed. In laboratory (Palermo), during the incubation period of both ovipositions, the T ranged from 11° C to 18° C with minimums of 6° C and 16° C and maximums of 14° C and 20° C, while humidity ranged from 60% to 84%. At the same time, in the field (Cinisi), the T ranged from 9° C to 17° C with minimums of 5° C and 15° C and maximums of 13° C and 19° C, while humidity ranged from 60% to 84%. Description of the eggs: 1 mm in diameter, spherical or oval, whitish, opaque, consisting of a membranous envelope covered by a poorly sticky mucus, which tends to make adhere small aggregates of soil. When they are close to hatching, the unborn embryo gives them an amber hue. The hatching was asynchronous: the young were born in 1–2 days. The protoconches of the young specimens measure 1.1 mm in diameter, amber in color with poorly hairy periostracum; whitish hairs, approximately 0.1 mm long; aperture with angled edges, both on the lower and upper margin; body light gray in color on neck, sides and sole, and dark gray on the cephalic area. Pseudoepifragma formation observed in a short period between January and February, during which the terrarium was exposed to wind conditions, and therefore, to a dehumidification of the soil. In this species, the pseudoepifragma appears as a transparent mucous formation with a whitish portion at the pneumostome; small soil aggregates have been found. The animal, retreating into its shell, carries with it small aggregates of soil that partially cover the outer mantle. The cryptic coloring of the inner mantle and of the periostracum camouflages the animal with the surrounding detritus and the soil on which it lives. Furthermore, the carinate and lenticular structure has an affinity with the fruits of the plant belonging to the genus *Medicago* (Fabaceae). Detritivorous diet: in addi-

Figures 13–18. The biological cycle of *Schileykiella mariarosariae* n. sp. observed in laboratory (Palermo). Fig. 13: during oviposition. Fig. 14: camouflaged specimen. Fig. 15: epifragma detail. Fig. 16: eggs in the soil. Fig. 17: juveniles newborn. Fig. 18: detail of the outer mantle and pneumostome.

tion to appreciating occasional pieces of vegetables such as cucumber in the laboratory, the specimens were mainly fed with fragments of dead and moistened leaves of *Asphodelus ramosus* L.

COMPARATIVE NOTES. *Schileykiella* is a genus of hygromiids characterized by the shell with pilose, yellowish or brown periostracum, right ommatophore retractor between penis and vagina, distal female genitalia without accessory organs (digitiform glands and dart-sac complex) and distal male genitalia with penial sheath and without penial papilla (Manganelli et al., 1989; Giusti & Manganelli, 1989; Cianfanelli et al., 2004).

Currently (Bank & Neubert, 2018), this genus is listed in the Canariellidae family which also includes the following genera: *Canariella* P. Hesse, 1918 (Canary Islands), *Debeauxhelix* Bacci, 1943 (Ethiopia), *Montserratina* Ortiz de Zárate López, 1946 (Spain and France mainland), and *Tyrrheniellina* Giusti et Manganelli, 1992 (Sardinia and Tuscan Archipelago: Islet of La Praiola, Capraia Islet) (see also Schileyko, 2006; Razkin et al., 2015; Bank, 2017).

Schileykiella is very close to *Tyrrheniellina* which would result from the loss of the penial papilla (Giusti & Manganelli, 1989, 1992).

The *Schileykiella* species, including *S. mariarosariae* n. sp., can be distinguished, morphologically and anatomically, as follows:

1. Shell discoidal, low conical above, with whorls, particularly the last, not or little angled. Genitalia with a very long flagellum and a very long duct of bursa copulatrix.....*S. reinae*

-. Shell lenticular or contabulate, flat or little elevated above, with whorls angled or keeled, particularly the last. Genitalia with flagellum and duct of bursa copulatrix shorter.....2

2. Shell lenticular, bigger, diameter 9–9.8 mm, yellowish in colour, with whorls strongly keeled, particularly 2–4, scanty pilose with hairs very short. Genitalia with penis long (4.5 mm), epiphallus short, flagellum long, duct of bursa copulatrix with a very flared initial portion...*S. mariarosariae* n. sp.

-. Shell contabulate, smaller, diameter 6.5–8.6 mm, brown in colour, with whorls angled, particularly 4, pilose with hairs longer. Genitalia with penis and flagellum shorter, duct of bursa copulatrix with little flared initial portion.....3

3. Shell with hairs long. Genitalia with epiphallus longer (2.5–2.9 mm), knob at base of flagellum absent, internal structure bordering vas deferens opening into penis absent.....*S. parlatoris*

-. Shell with hairs shorter. Genitalia with epiphallus short (1–1.6 mm), knob at base of flagellum present, internal structure bordering vas deferens opening into penis present.....*S. bodoni*

According to these taxonomic keys, it is possible to distinguish two main groups in *Schileykiella* genus: one that includes only *S. reinae*, and the second group with *S. mariarosariae* n. sp. that clearly differs from *S. parlatoris* and *S. bodoni*, more similar to each other.

STATUS AND CONSERVATION. The restricted distribution, with other obvious threats such as the nearby human presence and the fires that often flare up in these places, make *S. mariarosariae* n. sp. "Vulnerable", according to the Categories and Criteria of the IUCN Red List of Threatened Species (IUCN, 2017).

REMARKS. *Schileykiella mariarosariae* n. sp. is added to the long list of endemisms known for the Sicilian malacofauna. Like the other *Schileykiella* species, it can be considered a paleoendemism.

According to Giusti & Manganelli (1984) and Manganelli et al. (1989), these species had a Miocene origin, a subsequent differentiation in separate areas during the Pliocene and a dispersion, from their original sites, during the Pleistocene phases, when Sicily was again a single island.

The two genera with greater affinity, *Schileykiella* and *Tyrrheniellina,* could be descended, in turn, "*from an unique ancestral group of palaeoeuropean origin*"(Giusti & Manganelli, 1989).

Further research will allow us to expand our knowledge of these interesting Sicilian hygromiids and better understand the real phylogenetic and biogeographic relationships.

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Diversity of Phytoplanktonic populations along the Algerian coastline

Mustapha Boudjenah[1,2,*], Zakia Mokrane[2] & Dina Soualili[1]

[1]Department of Marine Sciences and Aquaculture, Faculty of Natural Sciences and life, Abedelhamid Ibn Badis University, BP 227, Mostaganem, Algeria; e-mail: boudjenahmust@yahoo.fr, soualilid@yahoo.fr
[2]CNRDPA/National Center for Research and Development of Fisheries and Aquaculture, 11 Boulevard Amirouche, Bou-Ismail, Tipaza, Algeria; e-mail: mokrane.zakia@gmail.com
*Corresponding author

ABSTRACT Phytoplankton biodiversity is the basis of the functioning of the aquatic ecosystems. Also, understanding and evaluating the effects of the change in our environment and their impact on planktonic populations is an important element. In fact, this paper was to appreciate the diversity and composition of phytoplankton in relation to some physicochemical parameters. Water samples were collected along the Algerian coastline (Alboran Sea, the Algerian basin and the Middle area), during the period May–June 2013. The study area contained a diversified phytoplankton community (296 species), belonging to 138 genera. The algal groups were represented and classified as dinoflagellates (180 species), diatoms (103 species), cyanophyceae, coccolithophorids, euglenids, and chrysophytes (13 species). The spatial distribution of cell densities revealed a heterogeneous phytoplankton composition dominated by dinoflagellates, which represent 63% of the total abundance, followed by diatoms (35%). Quantitatively, we observed a highest cell density and diatoms abundance in most stations of the Alboran Sea decreasing towards the east (Algerian basin). The peak of dinoflagellates in June was represented by *Prorocentrum* and *Gymnodinium* genera.

KEY WORDS Phytoplankton; diversity; physicochemical parameters; diatoms; dinoflagellates.

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INTRODUCTION

Phytoplankton is an important element in the marine ecosystem; this community is the basis of marine and freshwater food webs. Any change leads to variation of the trophic systems (Somoue et al., 2013), their composition fluctuations depending on hydrological conditions, such as light, temperature, salinity, pH, nutrients, and turbulence. Phytoplankton is known to exhibit rapid responses to changes in environmental conditions and is therefore commonly acknowledged as an excellent bioindicator of the impact of natural and seasonal changes in coastal ecosystems (Rimet & Bouchez, 2011). Changes in dominant base groups/species often propagate up the food chain, impacting on fish, marine mammals, and birds (Donnelly et al., 2007). Their susceptibility to environmental change is usually expressed by morphological and/or behavioral changes as well as by persistent or seasonal differences in abundance and distribution (Leterme et al., 2013). Qualitative and quantitative studies of phytoplankton allow us to recognize and describe the morphology of species,

and to analyse the dynamics of populations in time and space.

In recent years, "massive" growth of some phytoplanktonic species has been recorded along the Algerian coastline. These blooms are often linked to the eutrophication and anthropization of aquatic environments, and the nuisance that can be caused by hundreds of species may potentially present a risk to public health (David et al., 2012).

The information, concerning the composition of the phytoplankton community of the Algerian coast comes mainly from specific studies, referred to certain zones. While global data from across the Algerian coast are missing from the literature, nevertheless protection of marine ecosystems is a priority in the national development program of aquaculture and fishing activities in Algeria (Plan Aquapeche 2020, 2014).

The present study aims to explore the diversification and structure of phytoplankton populations observed on the Algerian coast during the period from May to June 2013 observed as a result of the analysis of the data collected during the prospecting Oceanographic campaign. It will reveal phytoplankton composition in three different zones of the Algerian coast, namely: the Alboran Sea, the Algerian basin and the Middle area.

The main hypothesis of this work is the influence of Atlantic waters on the structure of phytoplankton assemblages essentially, the diatom to dinoflagellate ratio.

This study will provide important information for future research, in relation to observed changes in the structure of the phytoplankton community due to the combined pressure of climate change and human impact in the Mediterranean.

MATERIAL AND METHODS

Study area

To gather information on different (qualitative and quantitative) aspects of the phytoplankton population along the Algerian coastline, the study was based on data collected during the assessment of demersal resources "ALDEM 2013" by CNRDPA (National Center for Research and Development Fisheries and Aquaculture).

The assessment of demersal resources "ALDEM 2013", which took place from May to June (2013) aboard the research vessel "Grine Belkacem", concerned the trawl bottoms of the Algerian coast at a depth from 20 to 800 m (Plateau and continental slope), Cape Segleb (36°56'45"N - 8°36'57"E), Algerian-Tunisian borders to Wadi Kiss (35°3'49"N - 2°12'50"W), Algerian-Moroccan borders. The Algerian coastline (Fig. 1) has been divided into three sectors: 1) the Alboran Sea: located in the western region of the Mediterranean Sea; its maximum width is 180 km at its eastern part, and a minimum of 14 km at the Strait of Gibraltar. The distance from the Strait of Gibraltar to the line between Cap de Gata (Almeria, Spain) and Cape Fegalo (Oran, Algeria) is 350 km. This imaginary line does not define a strict physical boundary, but an approximate delimitation of ecological processes and fluctuations in physical characteristics; 2) the Middle area: between the eastern limit of the Alboran Sea and the western boundary of the Algerian basin, goes from the wilaya of Tipasa to Tizi-Ouzou; 3) the Algerian basin: in the center of the western Mediterranean Sea, between the Algerian coasts and the Balearic Islands on the western side and the island of Sardinia on the east coast. Its width can reach about 280 km and extends over a length of about 500 km (Riandey et al., 2005).

In the present work, we named by "wilaya" a sampling site related to an administrative division (In English, Prefecture).

Sampling strategy and methods of phytoplankton analysis

The radials were selected in a grid pattern across the study region. During this campaign, in-situ hydrological measurements (temperature and salinity records) were carried out vertically by a CTD probe (Sea-Bird SBE 19 plus) and horizontally by a thermo-salinograph (Sea- Bird SBE 21) installed on board of the Research vessel. About 11 stations were chosen for the treatment and study of phytoplankton in this work, the position of these deferent study areas (Wilaya) is noted in Table I.

The phytoplankton dynamics study was divided into three distinct stages, i) sampling; ii) fixation, observation of the samples; and, finally, iii) the graphic and statistical processing of the data.

Sampling. Seawater for qualitative and quantitative study was carried out using 5 liter capacity

Niskin PVC bottles. The treatment protocol of this stand adopted in this study was based on the standards related to the Utermöhl method (Utermöhl, 1958). Phytoplankton were field-fixed immediately with Lugol's solution, conserved at low temperature (4° C) and in the dark to avoid photosynthesis. Finally, to achieve sedimentation of samples, each bottle was gently agitated for at least one minute, to homogenize its content. Utermöhl tanks were placed in sedimentation chambers (100 ml and 50 ml). The sedimentation time varied according to volume, from 24 to 72 hours (Ignatiades et al., 2009).

Observation and identification of species. Phytoplankton analysis was carried out in accordance with the recommendations of the Guide Standard for the Counting of Phytoplankton by Reverse Microscopy - Standard (Norme européenne NF EN 15204, 2006) of December 2006 - corresponding to Utermöhl method. A camera was very useful for validations of identifications and measurements. Determination of phytoplankton species was carried out at the specific level or, in case of difficulty or uncertainty, at higher taxonomic level (genus, family or class) using several keys and/or catalogues (Meunier, 1915; Schiller, 1933-1937; Taylor, 1976; Meave-del Castillo, 2009; Meave-del Castillo et al., 2012). Then, phytoplankton species were updated according to main taxonomic database sites, like algaebase.com, and World Register of Marine Species (WoRMS, 2019).

Data analysis. In this section, we were also interested in the variations of cell density of different species and genera in each station.

Diversity and structure of phytoplanktonic populations

Three main indices have been used, namely Shannon-Wiener, Equitability and Simpson.

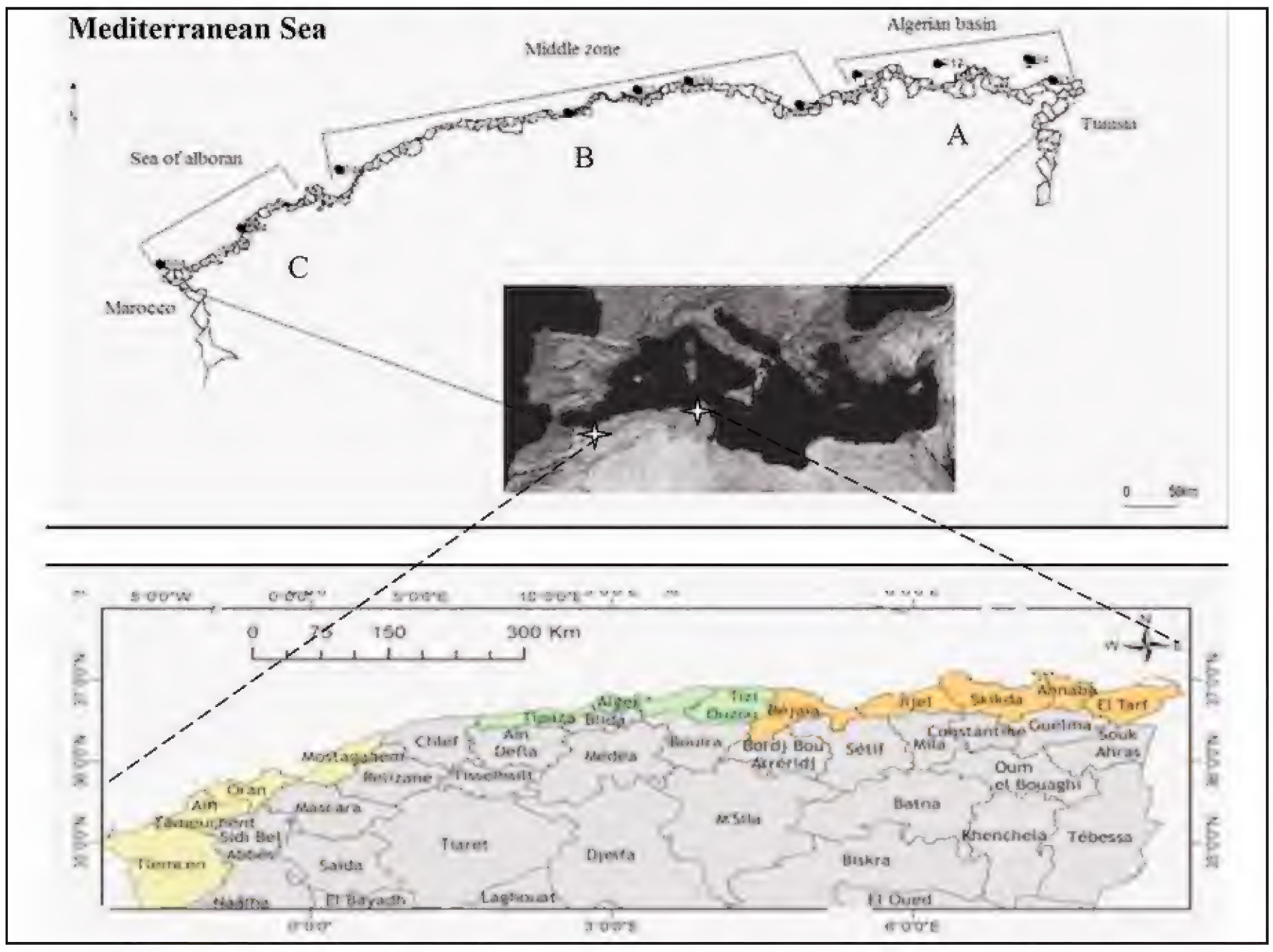


Figure 1. Localization of the study areas (site/wilaya) and subdivision of the Algerian coast.
A: Algerian basin; B: Middle area; C: Alboran Sea.

Zones	Wilaya	Stations	Longitude	Latitude	Distance to coast /m
Algerian basin	El Taref	S1	36° 55' 53.4606"	8° 18' 10.8"	1700
	Annaba	S11	37° 8' 43.0182"	8° 1' 14.4588"	28000
	Skikda	S12	37° 1' 18.12"	7° 14' 6.7806"	1900
	Jijel	S24	36° 54' 44.9388"	6° 3' 10.6806"	5100
Middle area	Bejaia	S26	36° 41' 18.3588"	5° 19' 50.6388"	4800
	Tizi-Ouzou	S30	36° 55' 21.7626"	4° 1' 25.3194"	2000
	Boumerdes	S34	36° 50' 14.5212"	3° 25' 29.8194"	7000
	Tipasa	S43	36° 36' 59.1006"	2° 35' 56.6406"	800
	Mostaganem	S46	36° 3' 7.2606"	-0° 5' 56.8788"	19000
Alboran Sea	Ain-Temouchent	S54	35° 29' 2.8782"	-1° 14' 25.9188"	1200
	Tlemcen	S64	35° 7' 44.4606"	-1° 11' 39.0114"	4000

Table 1. Geographical coordinates for each sampled site (wilaya) by region and its distance to the coast.

The Shannon Index indicates the number of species in a community in relation with stability of the environment; When the index is high, it is explained by a stable environment. This index is given by the following formula:

$$H' = ISh = -\sum Pi.\log Pi,\ Pi = ni/N$$

Pi: specific abundance; N: total number of phytoplankton population considered;
ni: number of individuals of the species "i".

This index varies in a range of - log S and + log S (S specific richness); The unit of information is the Bits.ind-1.

Equitability index: since diversity depends on both relative frequencies of the species and number of species that can vary widely from one stand to another,it is defined by the formula:

$$E(R) = ISh\ (bits) / \mathrm{Log}_2\ S\ (bits)$$

Equitability Index varies between "0" and "1"; it tends towards "0" when most of the cell density is concentrated on one species; it tends to "1" when all species have nearly the same abundance.

Simpson Diversity index (L): this index measures the probability that two individuals randomly selected belong to the same species for each given sample. It is given by the formula:

$$L=\sum e\ [ni(ni-1)] / [N(N-1)]$$

ni=number of individuals in species i, N=total number of individuals. The index is inversely proportional to diversity. When diversity is maximal its value is 0; when diversity is minimal the value tends to 1.

Diatoms/Dinoflagellates index: "Dia/Dino" index reflects the dominance patterns in the phytoplankton composition (Abundance or Biomass) (Helcom, 2014, 2016). The Dia/Dino index is defined by the following formula (Wasmund et al., 2017).

$$\text{Dia/Dino index} = Ab_{Dia} / (Ab_{Dia} + Ab_{Dino})$$

Ab_{Dia} = Diatoms abundance; Ab_{Dino} = Dinoflagellates abundance.

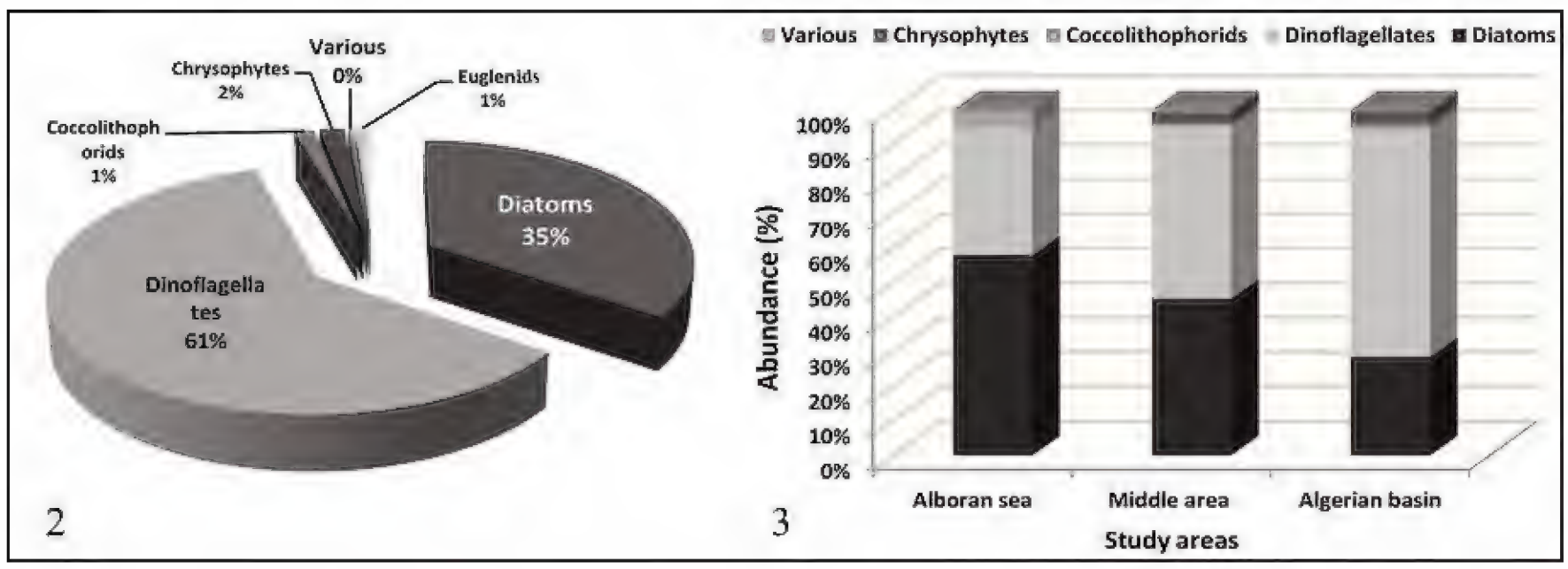
Seasonal averages of the biomass of planktonic diatoms (BM_{Dia}) have to be divided by the combined biomass or abundance (Ab_{Dia} or BM_{Dia}) of planktonic diatoms and autotrophic + mixotrophic dinofla-

gellates (Ab_{Dino} or BM_{Dino}). This leads to a simple absolute measure with values ranging from 0 to 1. If diatoms dominate, the value of the Dia/Dino index is >0.5; if autotrophic + mixotrophic dinoflagellates are dominant, the value of the index is <0.5.

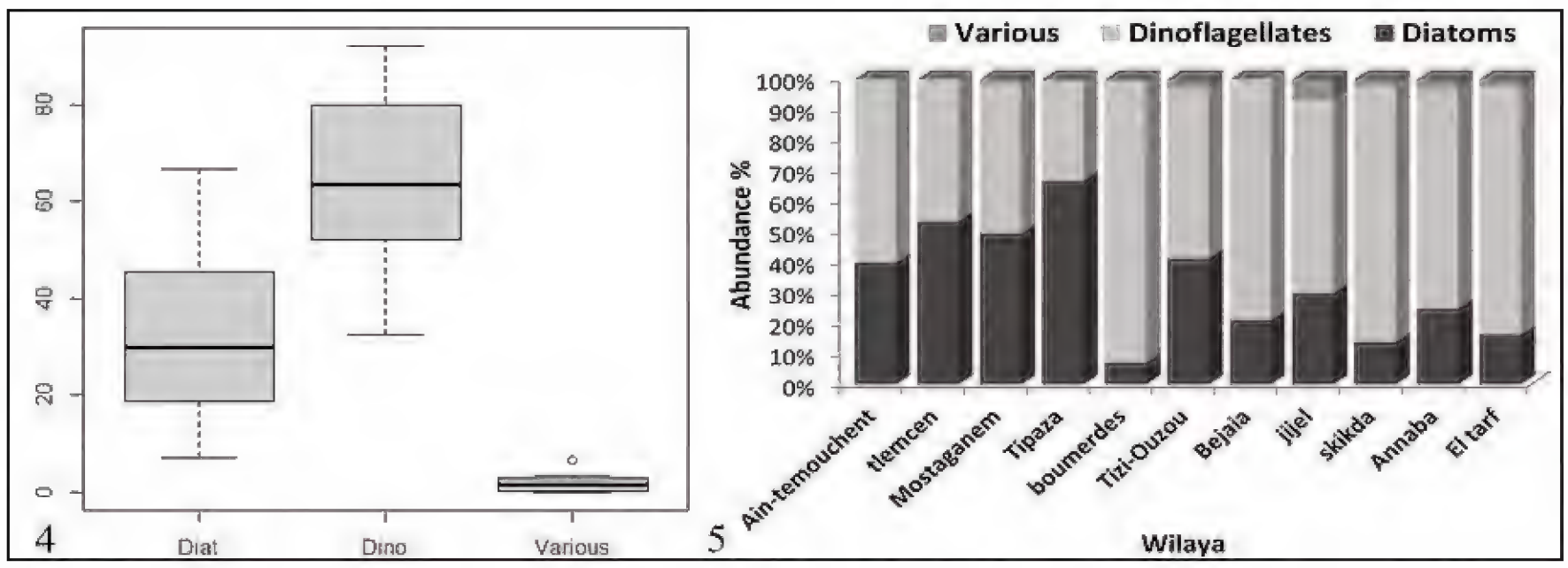
Principal component analysis (PCA): is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables. This analysis was based on correlation matrices applied to the parameters used in the study.

RESULTS

The inventory of phytoplankton species gives a total of 296 species distributed over the Algerian coast, grouped in 138 genera. In general, dinoflagellates are dominant with 180 species, followed by diatoms with 103 species. Another less frequent group was considered, it gathers the classes of Cyanobacteria, Euglenophyceae and Chlorophyceae (Figs. 2, 3). On the spatial level, the number of diatom species is higher in the Alboran Sea, inversely to the Algerian basin where dinoflagellates species are dominant. Equilibrium between diatoms and dinoflagellates was noted in the middle area. The specific richness "S" along the Algerian coastline is 296 species. It varies from one station to another and from one area (Wilaya) to another with an average value of 45 species. The lowest values were recorded in the Alboran Sea, precisely in both wilaya of Ain-Temouchent and Tlemcen with respective



Figures 2, 3. Specific richness "S" of the phytoplankton groups recorded in the study areas of the Algerian coastline. Fig. 2: specific richness of the phytoplankton groups. Fig. 3: spatial variation of the specific richness.



Figures 4, 5. Abundance of phytoplankton groups along the Algerian coastline. Fig. 4: abundance of phytoplanktonic groups presented in box and whiskers plot. Fig. 5: spatial variation of phytoplanktonic groups abundance.

values of 24 and 13 species. The most represented taxa in this zone are *Navicula* sp. and *Gymnodiuim* sp. Indeed, we recorded the highest specific richness values in the Algerian basin at the areas of Skikda and El-Tarf with respective values of S=108 and S=74 species. The observations recorded during our study show that the most important relative frequencies are due to the genera *Prorocentrum* and *Gymnodinium* in the Algerian basin. The Middle area specific richness varied between 28 and 47 species and the most important taxa observed were: *Prorocentrum mecans*, *Peridinium* sp., in Tizi-Ouzou and *Chaetoceros* sp., in Tipaza.

The results detailed in figures 4, 5 show the frequency and abundance variation of dominant phytoplanktonic groups at the target wilaya of three regions (Alboran Sea, Middle area and Algerian basin). For frequency (F), dinoflagellates and diatoms are the most frequent and constant phytoplankton groups (F>50%) compared to other taxonomic groups. The remainder of the phytoplankton composition indicates that the coccolithophorids are the rarest group (F<25%). This explains the fact that they are less competitive than the other microalgae. On the side of the Alboran sea we have an important presence of the diatoms with F>50% in both stations (Tlemcen, Ain-Temouchent). On the other hand, dinoflagellates constituted the constant phytoplankton groups in the different area of Algerian basin (Jijel, Skikda, Annaba, and El-Tarf). We noted, in the Middle area, a large frequency of diatoms in Tipaza wilaya, which

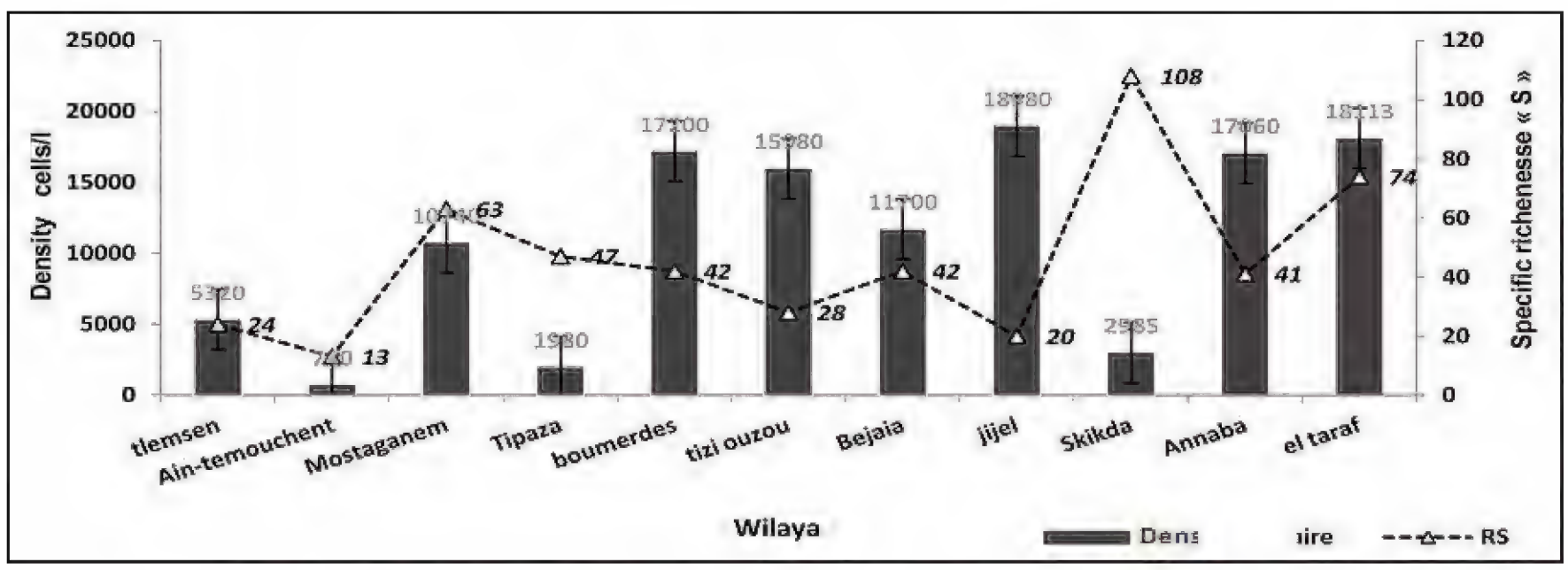
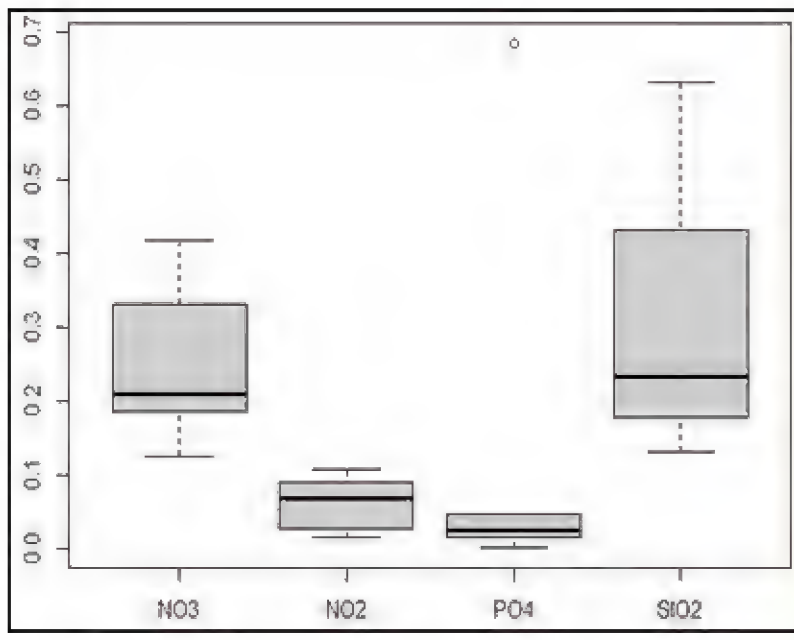


Figure 6. Spatial variation of the phytoplankton cell density in the study areas of the Algerian coastline (Average values).



Zone/ Parameters	Alboran Sea	Middle area	Algerian basin
Chl *a* µg/L	0.29	0.26	0.27
T°C	15.07	15.1	15.2
Salinity PSU	36.57	36.46	36.27
NO3 µmol/L	0.29	0.28	0.19
NO2 µmol/L	0.06	0.07	0.05
PO4 µmol/L	0.03	0.2	0.02
SIO2 µmol/L	0.38	0.23	0.33

Figure 7. Nutrients of samples collected from the Algerian coastline and spatial variations of environmental parameters.

is the closest to the eastern limit of the Alboran Sea. Whereas, on the other side, Tizi-Ouzou shows a dominance of dinoflagellates.

The observations recorded during our study, show that the most important relative frequencies are those of the genera *Prorocentrum* and *Gymnodinium* (F=58% and F=30%, respectively). In Diatoms, we recorded a relatively high value of the genera *Coscinodiscus*, *Chaetoceros*, *Melosira* and *Thalassiosira*, while the other genera of diatoms and dinoflagellates are marked by low frequencies (Fr<25%).

The preceding statement is also confirmed by the relative abundance values (Ab %) of diatoms which largely exceed the average value of 50% in the majority of stations of the Alboran Sea and slightly exceedes 35% in the wilaya of the Middle area. We have a phytoplankton abundance that is above average value in the different stations of the Algerian basin; indeed dinoflagellates contribute significantly to quantitative richness in this region with proportions exceeding 70%.

Figure 6 illustrates the distribution of total cell densities found in each region (Alboran Sea, Middle area and Algerian basin). We noted that low cell density was recorded at the wilayas of Ain-Temouchent, Tipaza and Skikda; while in the wilayas of Jijel, Annaba, Tizi-Ouzou and Boumerdes, we have a high cell density. Analysis of the diatom and dinoflagellate densities in phytoplankton populations shows that in the:

Alboran Sea: diatoms varied from 240 to 10200 cells/L and dinoflagellates from 360 to 10100 cells/L. The recorded observations show the lowest total cell density recorded along the Algerian coastline (740 cells /L) in Ain-Temouchent.

Algerian basin: the recorded observations show a total cell density ranging from 2985 cells/L (Skikda) to 18980 cells/L (Jijel) with large dominance of dinoflagellate groups.

Middle area: Dinoflagellates contribute significantly to phytoplankton production in this region. Wilaya of Boumerdes showed the highest phytoplankton total cell density in this sector; on the other hand, wilaya of Tipaza recorded the lowest concentration.

In Some Wilaya stations we noted a high phytoplanktonic concentration, corresponding to a low specific richness, which means that the population of these areas is dominated by one or two species (*Gymnodinium* sp.; *Prorocentrum* sp. in case of dinoflagellates; and *Melosira* sp. and *Chaetoceros* sp. in case of Diatoms).

Zone	Station (Wilaya)	Diatoms	Dinoflagellates	Dominant species	Diat/Dino index
Alboran Sea	**Tlemcen**	2720	2360	*Gymnodinium* sp	0.54
	Ain-Temouchent	240	360	*Navicula* sp	0.40
	Mostaganem	10200	10100	*Melosira* sp/ *Gymnodinium* sp	0.51
Middle area	**Tipaza**	2500	1220	*Chaetoceros* sp	0.67
	Boumerdes	6980	9360	*Gymnodinium* sp	0.43
	Tizi-Ouzou	1140	14600	*Prorocentrum micans*	0.07
	Bejaia	4840	18080	*Prorocentrum* sp	0.21
Algerian basin	**Jijel**	5680	12040	*Gymnodinium* sp	0.32
	Skikda	2700	16320	*Gymnodinium* sp	0.14
	Annaba	7700	22180	*Gymnodinium* sp	0.26
	El Tarf	8620	42900	*Prorocentrum* sp	0.17

Table 2. Spatial variation of Dia/Dina index in the study areas.

The Dia/Dino index shows only abundance data on diatoms and dinoflagellates (Table 2). It reflects the dominance patterns in the phytoplankton, the average value being around 0.5. As reported above, diatom dominance, (Dia/Dino index>0.5), was observed in two wilayas of the Alboran Sea area (Tlemcen; Mostaganem). In the wilayas of the Middle area the values of this index varied between 0.07 (Tizi-ouzou) and 0.67 (Tipaza). The minimum average value of this index was recorded in the eastern region confirming the dominance of the dinoflagellates, especially in Skikda.

The Shannon H' Index ranges from 0.86 to 1.9 bit/ind along the Algerian coastline (Table 3). These values are very close to the values of Hmax (log S), which varied between 1.3 and 2.02 bit /ind. The lowest value of this index (H'=0.86 bit /ind) was recorded in the wilaya of Tizi-Ouzou (Middle area) which moves away from the optimal value of Hmax. The wilaya of Skikda (Alboran Sea) was the most diversified area, as it presents the values closest to the optimal value (H'=1.85 bit /ind). The values of the equitability index (E) of each wilaya oscillate between 0.56 and 0.92. The minimum (tending to 0) is related to the wilayas of El Taref and Tizi-Ouzou, which means a specific dominance of a particular species or two, thus displaying an irregular spatial distribution. Actually, *Prorocentrum* sp. and *Gymnodinium* sp. resulted to dominate with 58% and 29% of relative abundance, respectively.

In the wilaya of Tipaza the maximum value of the index tends to "1", thus giving the image of a most diversified population with an equi-distribution. The spatial variation of the Equitability index is in decreasing order among the three studied regions, from the Aboran Sea (0.84) towards the Algerian basin (0.75). Conversely, the Simpson index shows average values increasing from the Alboran Sea (0.10) towards the Algerian basin (0.13).

The results of the spatial variations of temperature (°C), Chlorophyll a (Chla, in µg/L) value, Salinity (P.S.U), and the nutrients PO_4^{3-}, NO_3^{2-}, NO_2^{2-} and SiO_2 (µmol/L) of seawater samples collected from the Algerian coastline during May-June 2013 are shown in figure 7.

The normal thermal cycle was clear in this study period, and it was typical in all sector, ranging from a minimum of 14.6 °C at Ain-Temouchent (Alboran Sea) and a maximum of 15.9 °C at Skikda (Algerian basin), with a spatial mean value of 15.13 °C in the Algerian coastline.

The highest value of Chla, was recorded during this period at the Alboran Sea region precisely at Tlemcen (0.34 µmol/L) and the lowest at Skikda (0.23 µmol/L). Whereas, seawater salinity (P.S.U.) varied with small spatial differences with an average value of 36.42.

As far as nutrients are concerned, the reactive phosphate (PO_4^{3-}) was very low during spring and summer in all stations, whereas the maximum value was recorded at the eastern region (Algerian basin, 0.02 µmol/L). The dissolved nitrate (NO_3^{2-}) in the Algerian coast ranged between a maximum value of 0.41 µmol/L at Ain-Temouchent (Alboran Sea), and a minimum of 0.12 µmol/L in Jijel (Algerian basin). This variation is very limited for nitrite (NO_2^{2-}) with a spatial mean value of 0.06 µmol/L at all stations of the Algerian coast. In this study, the most important values of Silicium (SiO_2) concentration were related to the stations of Alboran Sea.

The principal component analysis (PCA) and the projection of the stations and hydrological variables in the plane of the I-II axes are illustrated in figure 6. This analysis was based on correlation matrices applied to total phytoplankton counts, phytoplankton classes, specific richness, and the physicochemical parameters. The first two axes I and II hold more than 83% of the total inertia. On this plane (I and II), some environmental variables (T° (C); S (P.S.U.), Chla; DC and PO_4; NO_3) are more explanatory of the phytoplankton abundances.

Several groups of wilayas have been identified according to their distance from the coast, physicochemical characteristics and phytoplanktonic abundance (Fig. 8).

Group I corresponds to wilayas of Alboran Sea and Middle area (Tlemcen; Ain-Temouchent, Tizi-ouzou and Tipaza). These wilayas are associated with a dominance of diatoms and characterized by high concentration of NO_3^{2-} and PO_4^{3-}.

Group II. Most of wilayas of the Algerian basin (Bejaia; El-Tarf; Annaba). The environmental variables are related to important phytoplankton abundances and, particularly, to those of dinoflagellates. The distance to the coast (DC) was the variable which gave a large contribution to the detachment of this 2nd group.

Groups III and IV are associated with a single wilaya for each group (Jijel; Skikda). Group III is linked to Jijel characterized by dominance of other

Zone	H'	J'	L	wilaya	H'	Log S	J'	L
Alboran Sea	1.18	0.84	0.10	Tlemcen	1.22	1.38	0.88	0.09
				Ain-temouchent	1.02	1.11	0.92	0.11
				Mostaganem	1.29	1.80	0.72	0.10
Middle area	1.21	0.74	0.12	Tipasa	1.53	1.67	0.92	0.05
				Boumerdes	1.40	1.62	0.86	0.06
				Tizi-Ouzou	0.86	1.45	0.60	0.23
Algerian basin	1.29	0.75	0.13	Bejaia	1.05	1.62	0.65	0.17
				Jijel	0.94	1.30	0.72	0.18
				Skikda	1.85	2.03	0.92	0.02
				Annaba	1.28	1.61	0.79	0.08
				El-Tarf	1.07	1.87	0.57	0.25

Table 3. Spatial variation of Shannon (H', H' max), Simpson (L) and Equitability "J" index per Wilaya.

phytoplanktonic taxa (Various); and group IV is linked to Skikda characterized by a high specific richness "S".

CONCLUSIONS

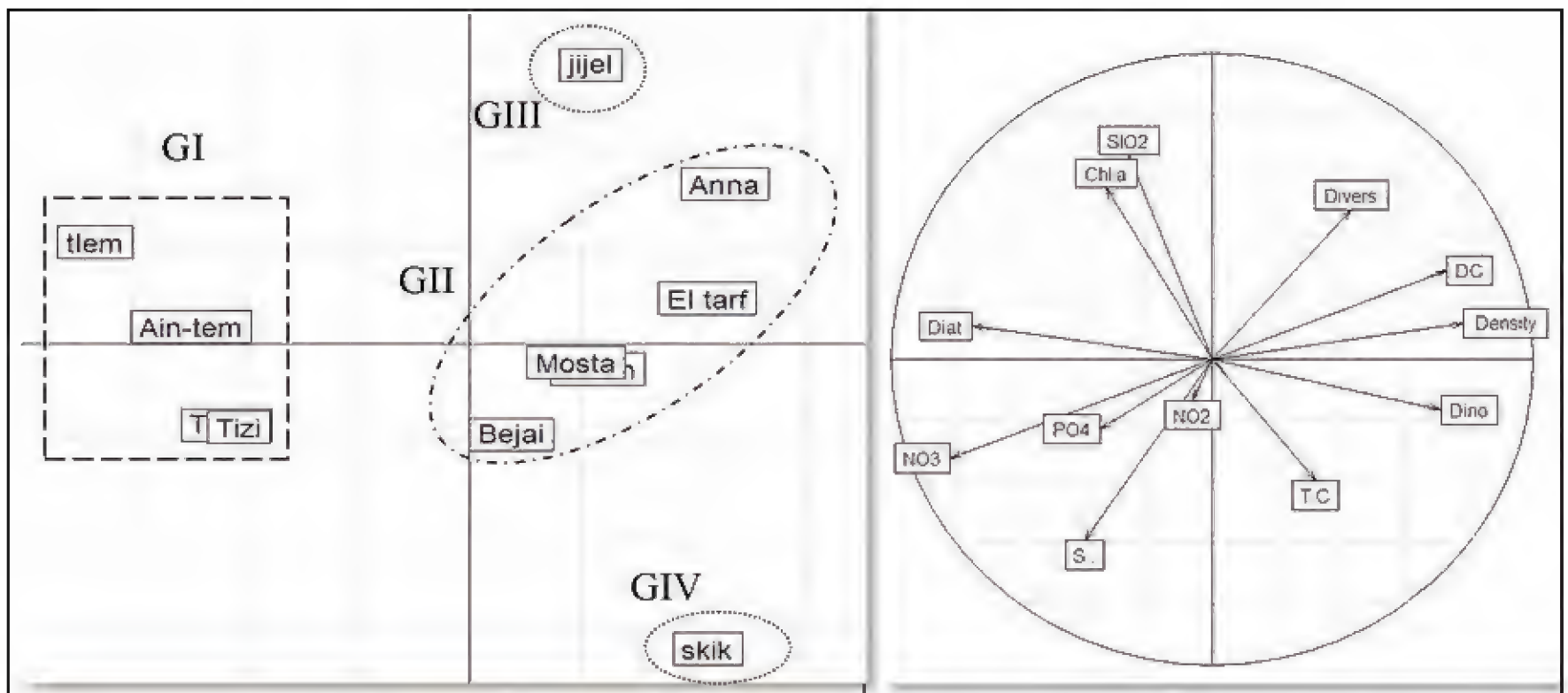
This study has shown remarkable phytoplankton richness with the presence of two main groups (diatoms and dinoflagellates). The qualitative study of phytoplankton based on samples collected by the CNRDPA during the period May-June 2013 by the GRINE BELKACEM vessel indicates the presence of 296 species identified in 11 stations distributed along the Algerian coast. Dinoflagellates and diatoms predominate in all stations with 103 and 180 species, respectively, along with the presence of other groups (in very low percentages) such as Coccolithophoridae and Euglenids. Our results are in line with those found in the Mediterranean by Ignatiades et al. (2009) who analyzed samples collected at nine stations (at an interval of 220 km minimum to a maximum of 558 km), and identified 216 species including 48 diatoms (22%), 112 dinoflagellates (52%) and 56 coccolithophores (25%). Besides, Moroccan Atlantic coasts presented, during the spring period 2013, a structure of the phytoplankton community composed of the same three phytoplankton groups dominated by diatoms with 47 taxa, followed by dinoflagellates with 34 taxa (Gallouli et al., 2014). The large number of phytoplankton species in common with those of the different Mediterranean ecosystems shows the wide geographical distribution of this microscopic flora and its strong relationship with the circulation of water bodies in the region.

Quantitatively, we observed a highest cell density and diatoms abundance in most stations of the Alboran Sea and decreases towards the east, where diatoms are replaced by dinoflagellates. This group of phytoplankton exhibited a remarkable quantitative richness with the dominance of main genera including *Prorocentrum*, *Gymnodinium* which were already reported by Gaumer (1981) in Algerian waters. This area identified as Alboran Sea is closer to the Strait of Gibraltar and is under the influence of Modified Atlantic Water (MAW), which arrives from the Atlantic along the Spanish coast in the Alboran Sea and then joins, via the Almeria-Oran jet, the North-African coast. It runs alongside the Straits of Sicily by the Algerian current. The dominance of diatoms on the coast of the Alboran sea shows that these regions are more prone to the influence of waters coming from the Atlantic at the surface, whose physico-chemical quality is different from that found in the Algerian basin where a dominance of dinoflagellates was observed. The disappearance of diatoms and their replacement by dinoflagellates was discussed in several studies (Wasmund et al., 1998, 2013, 2016; Alheit et al., 2005). According to some authors, this decline in the Dia/Dino index indicates a worsening of the en-

vironmental conditions. According to Lassus et al. (1982), dinoflagellates can develop with low concentrations of nutrients and salts, usually necessary for the development of phytoplankton.

The works carried out on the Algerian coasts by various authors (including Kruger, 1950; Lecal, 1952; Bernard & Bertoldo, 1958; Bucalossi, 1960; Lalami-Taleb, 1971; Illoul, 1991) have shown that, despite the large availability of nutrient reserves, Mediterranean waters in general and Algerian waters in particular remain relatively poor in phytoplankton. The concentration of chlorophyll a is directly related to the phytoplankton biomass, which depends on the supply of nutrients and, therefore, is a parameter commonly used in many works as indicator of the trophic state of the environment (Bricker et al., 1999). Ignatiades (2005) established the trophic status of the Aegean coastal waters according to chlorophyll a concentrations. When the concentration is less than 0.5 mg.m-3, the medium is oligotrophic. This allows us to consider the waters of the Algerian basin as oligotrophic. On the other hand, temperature and salinity are factors that influence the phytoplanktonic distribution. Wasmund et al. (1998, 2013, 2016) noted that the magnitude of the diatom bloom is controlled by the minimum winter temperature. This conclusion is supported by Klais et al. (2013) who report a large proportion of dinoflagellates in the vicinity of Algiers in Mediterranean waters (Salinity > 37 ppm), associated with strong surface illumination and the presence of small diatoms in winter and their blossoming in early spring. Bernard & Bertoldo (1958) in the same sector but in Atlantic-type waters, in the Alboran Sea area, reported, on the contrary, the preponderance of diatoms. Bucalossi (1960), in waters of the same type, found an influx of dinoflagellates when salinity increases.

Diversity can influence the primary production and abundance of phytoplankton; some authors have studied the relationship between productivity and biodiversity of ecosystems, but the form of the relationship is variously reported as a negative lin-



	F1	F2	F3
Eigen values	3.37	2.33	1.42
%Variance totale	67.92	32.08	16.78
% Cumulative	48.64	83.22	100

Abbreviation of wilayas (Sampled sites): **skik**: Skikda; **Bejai**: Bejaia; **Tizi**; Tizi-ouzou; **Ain-tem**: Ain temouchent; **El tarf**: El taref; **Mosta**: Mostaghanem; **tlem**: Tlemcen; **Tipa**: Tipaza; **Anna**: Annaba; **Boum**: Boumerdes.

The analysis was performed using the average value of data.
S: salinity; **TC**: Temperature; **PO_4**: phosphate concentration; **NO_3**: nitrate concentration; **NO_2**: Nitrite concentration, **Chl*a***: chlorophyll a; **SIO_2**: Silicium ; **DC**: Distance to coast, **Diat**: Diatoms density; **Dino**: Dinoflagellates density; **Divers**: Various groups density; **Density**: Total phytoplanktonic density.

Figure 8. The principal component analysis (PCA) and the projection of the stations and hydrological variables in the plane of the I-II axes.

ear relationship, a positive linear relationship, a unimodal relationship or, still, no relation (Chase & Leibold, 2002; Jouenne et al., 2007; Claquin et al., 2010).

There is a negative relationship between specific richness and cell density because high production is associated with low biodiversity due to the dominance of one or a few species that exclude other taxa from the ecosystem. In the wilaya of Skikda and Tipasa a very low cell density was noted, but at the same time a good specific richness. While in Jijel, Annaba, Tizi-Ouzou and Boumerdes we have a large cell density but a low specific richness, which means that the populations in these regions are dominated by one or two species. The complexity and variability of environmental factors may explain the heterogeneity of the diversity-productivity relationship, as well as the different methodologies used to describe the degree of diversity (Napoléon et al., 2014). Alternatively, sampling strategy is another factor that may cause this fluctuation and an unbalanced distribution.

The combined action of climate change and the impact of anthropogenic activities in the Mediterranean suggest changes in the perspectives for the structure and diversity of phytoplankton populations; this study provides useful background information and a framework for future research.

Finally, this work contributes to understanding the functioning of a coastal ecosystem along with the composition of phytoplankton populations, especially according to the spatial variation. Indeed, it will be more interesting, as a prospect, to continue this study according to the different seasons thus ensuring the follow-up of phytoplankton successions throughout the year.

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Presence of the European polecat, *Mustela putorius* Linnaeus, 1758 (Mammalia Mustelidae), in Aspromonte National Park, Italy

Giacomo Gervasio[1*], Antonino Siclari[2], Sergio Tralongo[2], Salvatore Urso[1] & Francesca Crispino[1]

[1]Società Greenwood, via Pozzillo 21, 87045 Dipignano, Cosenza, Italy
[2]Ente Parco Nazionale dell'Aspromonte, Via Aurora, 89057 Santo Stefano in Aspromonte, Reggio Calabria, Italy
[*]Corresponding author, email: giacomogervasio@greenwoodstudiecologici.it

ABSTRACT In the recent past, the presence of the European polecat, *Mustela putorius* Linnaeus, 1758 (Mammalia Mustelidae), in the Aspromonte National Park (Italy) appears to be uncertain due to the lack of objective data and specific studies. In 2017–2018, the Park Authority carried out a project to monitor seven species of mesocarnivores whose status is poorly known even at the local level. Monitoring was performed by means of camera trapping, a technique particularly suitable for the detection of very elusive species. During the second year of activity, the presence of the European polecat was recorded in two different areas of the north-eastern side of Aspromonte National Park, the southernmost part of its Italian distribution.

KEY WORDS *Mustela putorius*; presence; demography; mustelids; Aspromonte.

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INTRODUCTION

The European polecat, *Mustela putorius* Linnaeus, 1758, is a small carnivorous mammal of the family Mustelidae recognizable by its characteristic light facial mask. The species can live in very different habitats, generally below 1500 m a.s.l. It can be found in ruderal zones, in various forest formations, in landfills or in wet environments, which it prefers. However, it generally favours areas with little human presence. In Europe, the polecat is distributed from the Iberian Peninsula to the Urals, with its northern limit being Wales, Sweden and southern Finland. In Italy, it is present in most of the peninsula, probably in a discontinuous manner, but is lacking in Sardinia and Sicily. The species is considered to be declining throughout Europe, albeit locally stable (Weber, 1988; Lodé, 1988).

Historical information on the European polecat in Aspromonte National Park is not particularly precise, given the lack of reliable reference data. Moschella (1900) reported its presence in the province of Reggio Calabria. In the Park Plan (AA.VV., 2009), the species is indicated as only potentially present, even though there are many suitable environments within the Park. In 2017, the Park Authority carried out a project to monitor seven species of mesocarnivores by means of camera trapping: red fox *Vulpes vulpes* Linnaeus, 1758, European badger *Meles meles* (Linnaeus, 1758), pine marten *Martes martes* (Linnaeus, 1758), beech marten *Martes foina* (Erxleben, 1777), European polecat *M. putorius*, least weasel *M. nivalis* Linnaeus, 1766, and European wildcat *Felis silvestris* Schreber, 1777. Particular attention was given to the collection of data on the European polecat on account of the lack of knowledge about its status, even at the local level.

MATERIAL AND METHODS

Monitoring was performed by means of camera trapping, a technique considered particularly suitable for the detection of very elusive species. The methodological approach was opportunistic, aimed at recording presence data in sample areas. The choice of trapping stations was based on studies of the ecological requirements of the various species and on a careful landscape analysis to identify the different environmental types representative of the study area. During the camera trap positioning, particular attention was given to the identification of runs, trails and ditches located near wet areas. For the surveys carried out in 2017, 15 stations were identified. In some of them considered particularly suitable, an additional camera trap was positioned to increase the capture possibilities. In total, 20 camera traps have been active for 4 weeks (from mid-February to mid-May) in different recording sessions. In 2018, the sampling strategy was revised to further maximize the possibility of positive results. Compared to the previous year, additional camera trapping sessions were performed on the north-eastern side of the Park and in other sample areas thought to be particularly favourable but not covered by the previous surveys. In this phase, 9 trapping stations were identified and 12 camera traps were set up, which remained active for a continuous session of 12 weeks (from mid-March to mid-June). In both years, the camera traps have been positioned at a height of 30-50 cm above ground near wildlife runs. Olfactory bait-attractants were used to attract the species to the camera trap.

RESULTS AND CONCLUSIONS

The monitoring activities carried out in 2017–2018 recorded 13 species of wildlife, including the certain presence of the European polecat in two different areas on the north-eastern side of Aspromonte National Park. In both cases, the trapping stations were chosen at the edges of watercourses with abundant cover of shrub and riparian vegetation, respectively at an altitude of 170 m a.s.l. and 575 m a.s.l. Table 1 summarizes the camera trapping data for the European polecat.

The European polecat was recorded only in the second year of activity and with a very small number of independent contacts. This demonstrates the difficulty of recording a species with particularly low densities and confirms the need to keep the photographic equipment in the field for sufficiently long times to detect the species' presence (Fusillo & Marcelli, 2014). Prior to this study, knowledge of the presence of the European polecat in the Aspromonte area was based on bibliographical reports from the last century (Moschella, 1900) and on considerations of its potential presence with reference to the availability of suitable habitats (Park Plan). Therefore, our results should be considered the first certain record of the recent presence of the species in the southernmost part of its Italian distribution range.

Station ID	Period	Recording time (h)	No. independent contacts	Time of record	Trap rate
2	15/03/2018 17/06/2018	2224	1	03:36	0.04
4 bis	15/03/2018 17/06/2018	2230	1	20:41	0.04

Table 1. Recording time expressed in hours of operation; number of independent contacts (i.e. photos of individuals of the same species taken at least 1 hour apart or of morphologically distinguishable individuals); trap rate (number of independent contacts/monitoring hours *100).

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Entomofauna investigations in the apricot orchards, *Prunus armeniaca* L. (Rosales Rosaceae), in Ouled Si Slimane, Batna, North East Algeria

Smail Chafaa[1*], Sabrina Belkhadria[1] & Fateh Mimeche[2]

[1]Department of Ecology and Environment, University of Batna 2, 05078 Batna, Algeria
[2]Department of Agricultural Sciences, University of M'Sila, 28000 M'Sila, Algeria
[*]Corresponding author, e-mail: chafaasmail@gmail.com

ABSTRACT Researches carried out in the past years allowed to list an entomofauna that lives on the apricot orchards, *Prunus armeniaca* L. (Rosales Rosaceae), in Ouled Si Slimane (Batna Department, Algeria). The investigated period was from October 2014 until May 2015. The sampling techniques used were: hunting in sight, barber pots, colorful traps, entomological umbrella and the filleting net. We have identified a total of 125 species divided into 9 orders and 54 families in which Coleoptera and Hymenoptera were quantitatively represented. The phytophagous were the most present. Its Shannon Value exceeds 4.5 Bits and indicates a Specific Richness of the insects and diversification of ecological niches in this kind of fauna.

KEY WORDS Apricot; entomofauna; orchard; Coleoptera; Hymenoptera.

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INTRODUCTION

In Algeria, apricot cultivation, *Prunus armeniaca* L. (Rosales Rosaceae), is distributed in coastal plains, Tellian Atlas, high plateaus, pre-desert areas and Saharan Oases (Chafaa, 1992). The apricot's pests are few and rarely specific. Their population varies significantly in space and time (Chafaa, 1992). According to Vidaud (1980), these pests are generally classified according to their level of attack. The root, neck, trunk and branch pests are represented by several species (Hariri, 1978; Bretaudeau, 1979; Malek, 1987).

Due to the economic and social importance of apricot, its culture has been the subject of research and experimentation for years to improve its productivity.

In Algeria, some works are published on the apricot: Chaouia (1987), on the varietal behaviour of the species in the Boufarik experimental station (Blida Department), Bouzidi (1990) in Batna Department, Derias (1984), Benabbes (1990) and Achourri (1991) in the region of Ain Touta and on apricot berry dieback in the N'Gaous region, Chafaa (1992) in the region of Ouled Si Slimane on the ecological biology of apricot zoocoenosis. Numerous are the publications on this subject also in other countries (see, for example: Ivanova, 1991, 2006; Dér et al., 2003; Bonsignore et al., 2008).

This work has the main objective to highlight apricot entomofauna subservient to the agro-systems in Ouled Si Slimane orchards. Thus, we aim in our study to know the bio-ecological status of the different insect groups: abundance, diversity and diet.

MATERIAL AND METHODS

Our study was conducted in an apricot orchard in the Kochbi region located about 5 km from Ouled Si Slimane city (Lat. 35°36'39"N, Long. 5°37'58"E). This region is 90 km from Batna department, in north east Algeria. The climate of the study area during the period 1985–2014 was characterized by a total average precipitation of 251.59 mm, the average temperature varied between 0.03°C in January and 36.75° C in July. The study area is in an arid bioclimatic stage with cool winters.

This orchard, of one hectare of surface, was installed in 1992 and includes a total of about 100 trees of apricot variety of Louizi or "Louzired" . The trees are cultivated in semi-intensive form with 6m x 6m spacing; each tree measures 3 m in height. Soil is a clay-silty texture and it is irrigated by a channel. In addition, fertilization of the soil with farm manure is carried out during the period from December to January, the weed control applied is mechanical in the cuvettes and the orchard does not undergo any phytosanitary treatment.

The study of the entomofauna was carried out between October 2014 to May 2015. We have adopted a qualitative sampling (classical hunting) (Colas, 1974) and a quantitative sampling using different methods: striking (Fauvel et al., 1981), trapping (colored traps, Barber pots, etc.) and mowing (Benkhelil, 1991).

Samples were kept at the laboratory in petri dishes or in labelled flasks. They were checked under the binocular microscope for the sorting and counting and they were determined using morphological characters. The determination was made using various identification keys: Perrier (1964), Chopard (1943), Severa (1988), Berland (1999), Dierl & Ring (2009), Bouragba (2010), and Aguib (2014).

The indexes used to examine the bio-ecological status of the different insect groups in the apricot orchard during the study period (Magurran, 2004), were: Abundance frequency (FA) has been calculated for each order by the percentage of individuals in relation to the total (N) recorded in the orchard, Species richness (S), Shannon's diversity index (H'), and Evenness (E).

RESULTS AND CONCLUSIONS

The results on the entomofauna sampled in the study area are shown on Table 1 with its numbers (ni) and its abundance frequencies (FA%) depending on the species. All species are classified according to their taxonomic membership and diet (D).

The insect inventory has identified a total of 125 species belonging to 9 orders and 54 families with a total of 4,170 individuals (Table 1). Similar results were obtained by Naceri (2011) in an olive grove in Batna with a total of 156 species and 1528 specimens belonging to 16 orders and 80 families. Chafaa (2013) recorded in three olive groves in the region of Batna 206 species of insects with a total of 2311 specimens belonging to 11 orders and 74 families.

The species *Henicopus* sp., from the Dasytidae family (Coleoptera), is considered the most abundant species in our orchard with an abundance frequency of abundance of 42.45%, followed by *Cataglyphis bicolor* of the Formicidae family (Hymenoptera) with a frequency of abundance of 5.18%. Several authors show the dominance of Coleoptera in the region of Batna: Kellil (2010) in cereal fields, Zireg (2011) in a juniper forest, and Naceri (2011) in an olive grove. Guettala-Frah (2009) shows the dominance of Coleoptera (38%) in an apple orchard in the Aurès region (Batna Department).

Among the species recorded, we have the presence of 4 species protected by regulations in Algeria (Decree No. 83-509 of 20/08/1983) related to non-domestic animal species. These species are: *Coccinella septempunctata*, *Apis mellifera*, *Cataglyphis bicolor*, and *Polistes gallicus*.

The diversity parameters calculated for the different types of the diet are recorded in Table 2. According to the results, we note a dominance of phytophagous with 71 species, followed by predators with 31 species and polyphagous with 13 species. We report a very low number of saprophagous (5), parasites (4) and coprophagous (1) species.

Phytophagous insects are very selective for plant species that they prefer. All parts of the plant can be attacked by xylophagous, frondicultural, radicicols, Saproxylic, and floricols insects (Villiers, 1979; Ricklefs & Miller, 2005).

Families	Species	D	Ni	FA(%)
Blattoptera				
Blattidae	*Blatta orientalis*	Pol	4	0.10
Coleoptera				
Aphodiidae	*Aphodius* sp.	Cop	1	0.02
Buprestidae	*Acmaeoderella discoidea*	Phy	44	1.06
Buprestidae	*Capnodis tenebrionis*	Phy	2	0.05
Buprestidae	*Perotis unicolor*	Phy	1	0.02
Cantharidae	*Cantharis* sp.	Pre	5	0.12
Cantharidae	*Cantharis* sp 1	Pre	4	0.10
Carabidae	*Amara* sp. 1	Pre	2	0.05
Carabidae	*Amara* sp. 2	Pre	4	0.10
Carabidae	*Calathus fuscipes algiricus*	Pre	64	1.53
Carabidae	*Calathus* sp.	Pre	1	0.02
Carabidae	*Carabus* sp.	Pre	2	0.05
Carabidae	*Lebia trimaculata*	Pre	1	0.02
Cetoniidae	*Aethiessa floralis*	Phy	3	0.07
Cetoniidae	*Cetonia funeraria*	Phy	4	0.10
Cetoniidae	*Tropinota hirta*	Phy	12	0.29
Chrysomelidae	*Chrysolina* sp.	Phy	3	0.07
Chrysomelidae	*Cryptocephalus rugicollis*	Phy	1	0.02
Chrysomelidae	*Entomoscelis rumicis*	Phy	6	0.14
Chrysomelidae	*Oulema melanopus*	Phy	9	0.22
Cleridae	*Trichodes alvearius*	Phy	6	0.14
Coccinellidae	*Coccinella septempunctata*	Pre	4	0.10
Curculionidae	*Hypera postica*	Phy	1	0.02
Curculionidae	*Larinus* sp. 1	Phy	1	0.02
Curculionidae	*Larinus* sp. 2	Phy	9	0.22
Curculionidae	*Lixus* sp.	Phy	5	0.12
Curculionidae	*Plagiographus excoriatus*	Phy	3	0.07
Curculionidae	*Rhytidoderes plicatus*	Phy	2	0.05
Curculionidae	*Scolytus rugulosus*	Phy	15	0.36
Dasytidae	*Henicopus* sp.	Phy	1770	42.45
Geotrupidae	*Geotrupes* sp.	Sap	3	0.07
Meloidae	*Mylabris schreibersi*	Phy	1	0.02
Meloidae	*Mylabris* sp.	Phy	1	0.02
Melolonthidae	*Amphimallon* sp.	Phy	1	0.02
Melolonthidae	*Rhizotrogus pallidipennis*	Phy	6	0.14
Melolonthidae	*Rhizotrogus* sp.	Phy	7	0.17
Scarabaeidae	Scarabaeidae	Phy	1	0.02
Staphylinidae	*Othinus punctulatus*	Pol	2	0.05
Staphylinidae	*Philonthus politus*	Pol	1	0.02
Staphylinidae	*Staphylinus* sp.	Pol	9	0.22
Tenebrionidae	*Adesmia faremonti*	Pre	1	0.02
Tenebrionidae	*Omophlus* sp.	Pre	3	0.07
Tenebrionidae	*Sepidium variegatum*	Sap	3	0.07
Tenebrionidae	*Tentyria* sp.	Sap	1	0.02
Tenebrionidae	*Tentyria thunbergi*	Sap	2	0.05
Tenebrionidae	*Tribolium* sp.	Sap	2	0.05
Dermaptera				
Forficulidae	*Forficula auricularia*	Pol	1	0.02
Diptera				
Anthomyiidae	*Delia radicum*	Pre	1	0.02
Asilidae	*Asilus* sp.	Pre	1	0.02
Bombyliidae	*Bombylius major*	Pre	19	0.46
Calliphoridae	*Calliphora vomitoria*	Pol	1	0.02
Calliphoridae	*Lucilia caesar*	Pol	11	0.26
Culicidae	*Culex pipiens*	Pol	28	0.67
Muscidae	*Musca domestica*	Pol	562	13.48
Sarcophagidae	*Sarcophaga carnaria*	Pre	96	2.30
Syrphidae	*Scaeva pyrastri*	Pre	1	0.02
Syrphidae	*Syrphus* sp.	Pre	100	2.40
Tachinidae	*Gymnosoma rotundatum*	Pol	1	0.02
Tachinidae	*Phryxe vulgaris*	Pol	12	0.29
Tachinidae	*Tachina fera*	Pol	4	0.10
Tachinidae	*Tachinus* sp.	Pol	12	0.29
Hemiptera				
Anthocoridae	*Anthocoris* sp.	Phy	80	1.92
Cicadellidae	*Iassus lanio*	Phy	38	0.91
Cicadidae	*Cicada* sp.	Phy	3	0.07
Cicadidae	*Cicadetta* sp.	Phy	4	0.10
Pentatomidae	*Pentatomidae* sp.	Phy	1	0.02
Reduviidae	*Reduvius personatus*	Phy	1	0.02
Rhopalidae	*Corizus* cf. *hyoscyami*	Phy	1	0.02
Scutelleridae	*Eurygaster maura*	Phy	1	0.02
Homoptera				
Aphididae	*Macrosiphum rosa*	Phy	2	0.05
Aphididae	*Myzus persicae*	Phy	1	0.02
Aphididae	*Myzus* sp.	Phy	5	0.12
Hymenoptera				
Apidae	*Apis mellifera*	Phy	272	6.52
Apidae	*Bombus* sp.	Phy	87	2.09
Apidae	*Eucera punctatissima*	Phy	3	0.07
Apidae	*Nomada cinnabarina*	Phy	1	0.02
Megachilidae	*Rhodanthidium siculum*	Phy	5	0.12
Crabronidae	*Larra anathema*	Pre	1	0.02
Chrysididae	*Chrysis cuprea*	Par	8	0.19
Chrysididae	*Chrysis ignita*	Par	3	0.07
Chrysididae	*Chrysis trimaculata*	Par	2	0.05

Table 1/1. Systematic list with inventoried insects, diet (D), numbers (ni) and frequency of abundance calculated for the study area (FA%). Pol: Polyphaga, Phy: Polyphaga, Pre: Predators, Par: Parasites, Sap: Saprophagous, Cop: Coprophagous.

Families	Species	D	Ni	FA(%)
Chrysididae	*Chrysis* sp.	Par	1	0.02
Formicidae	*Aphaenogaster* sp.	Pre	15	0.36
Formicidae	*Cataglyphis bicolor*	Pre	216	5.18
Formicidae	*Cataglyphis* sp.	Pre	46	1.10
Formicidae	*Crematogaster auberti*	Pre	56	1.34
Formicidae	*Crematogaster scutellaris*	Pre	9	0.22
Formicidae	*Crematogaster* sp.	Pre	1	0.02
Formicidae	*Messor barbarus*	Pre	148	3.55
Formicidae	*Tapinoma nigerrimum*	Pre	35	0.84
Halictidae	*Sphecodes fuxipennis*	Phy	1	0.02
Megachilidae	*Anthidium laterale*	Phy	1	0.02
Megachilidae	*Hoplitis anthocopoides*	Phy	2	0.05
Megachilidae	*Hoplitis* sp.	Phy	54	1.29
Megachilidae	*Osmia anceps*	Phy	2	0.05
Megachilidae	*Osmia pinguis*	Phy	6	0.14
Megachilidae	*Osmia* sp.	Phy	60	1.44
Megachilidae	*Osmia tricornis*	Phy	14	0.34
Megachilidae	*Osmia tridentata*	Phy	2	0.05
Pompilidae	*Anoplius* sp.	Phy	2	0.05
Sphecidae	*Ammophila sabulosa*	Pre	1	0.02
Vespidae	*Polistes gallicus*	Pre	1	0.02
Vespidae	Vespidae	Pre	2	0.05
Vespidae	*Vespula germanica*	Pre	1	0.02
Lepidoptera				
Lycaenidae	*Lycaena* sp.	Phy	29	0.70
Lycaenidae	*Lycaena* sp.	Phy	2	0.05
Lycaenidae	*Polyommatus icarus*	Phy	1	0.02
Nymphalidae	*Melanargia* sp.	Phy	1	0.02
Nymphalidae	*Vanessa cardui*	Phy	4	0.10
Papilionidae	*Papilio machaon*	Phy	1	0.02
Pieridae	*Colias croceus*	Phy	3	0.07
Pieridae	*Pieris brassicae*	Phy	1	0.02
Pieridae	*Pieris rapae*	Phy	1	0.02
Pieridae	*Pontia daplidice*	Phy	10	0.24
Orthoptera				
Acrididae	*Acrotylus patruelis*	Phy	1	0.02
Acrididae	*Aiolopus thalassinus*	Phy	9	0.22
Acrididae	*Calliptamus italicus*	Phy	1	0.02
Acrididae	*Sphingonotus* sp.	Phy	1	0.02
Gryllidae	*Gryllus campestris*	Phy	3	0.07
Gryllidae	*Gryllus* sp.	Phy	8	0.19
Gryllidae	*Oecanthus pellucens*	Phy	7	0.17
Mantidae	*Mantis religiosa*	Pre	1	0.02
Pamphagidae	*Ocneridia longicornis*	Phy	1	0.02
Pamphagidae	*Ocneridia* sp.	Phy	3	0.07
Pyrgomorphidae	*Pyrgomorpha cognata*	Phy	4	0.10

Table 1/2. Systematic list with inventoried insects, diet (D), numbers (ni) and frequency of abundance calculated for the study area (FA%). Pol: Polyphaga, Phy: Polyphaga, Pre: Predators, Par: Parasites, Sap: Saprophagous, Cop: Coprophagous.

Predatory species and polyphagous species are fairly well represented in study stations. Following Dajoz (2003), polyphagous species have a more eclectic diet. The polyphagous feed on animal and plant organic matter in different forms and they can therefore play a dual role. Predatory species can feed different prey during their life and their voracity is a useful indicator of their repressive potential; these characteristics affect the dynamics of predator-prey numerical interactions and the repressive effect expected from the study of predators (Hassell, 1978). A polyphagous predator uses several species of prey and the importance of each varies according to its relative availability (Coutier & Cloutier, 1992). Coprophages, saprophagous and parasites are poorly represented in our inventory despite their roles in the functioning of agrosystems. Coprophages contribute to soil formation through burrowing and the incorporation of organic matter (Bachelier, 1978) and they help to structure the soil with the recycling of dung in the soil supplying nitrogen in the soil (Dajoz, 1985).

The saprophagous use all the dead substances, in particular the decaying vegetable detritus, by the action of the microorganisms, the mushrooms, and then the insects which will constitute the humus (Villiers, 1979; Lamy, 1999).

According to Beaumont & Cassier (1983), there is no absolute trophic specialization in nature, so the distribution considers the type of diet of the adult states.

The Shannon index (H') for the three categories of phytophagous, predators and polyphagous is high compared to the other categories (parasites, saprophagous and coprophages) for the Ouled Si Slimane station (Table 2).

This index gives an idea of the diversity of all population considering not only the number of species, but also the number of individuals from the different trophic populations. A community is even more diverse when the Shannon's diversity index (H') is bigger. This index shows that the station Ouled Slimane is home to more diverse populations.

The equitability (E) of predators, polyphagous and phytophagous is high compared to parasites, coprophages and saprophagous (Table 2). This shows that the trophic categories in the study orchard are less balanced.

Coprophagous	Saprophagous	Parasites	Polyphagous	Predators	Phytophagous	
1	11	14	648	842	2654	**N**
1	5	4	13	31	71	**S**
0	0.02	0.03	0.42	0.47	0.41	**H'**
0	2.32	2	3.7	4.95	6.15	**H'max**
0	0.01	0.01	0.11	0.09	0.07	**E**

Table 2. Total richness (S), the Shannon index (H') and the equitability (E) of the insects identified by the diet.

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Relative biomass and size class of ant prey *Cataglyphis bicolor* (Fabricius, 1793) (Hymenoptera Formicidae) in the Reghaïa wetland reserve (Algeria)

Ouarab Samia[1*] & Doumandji Salaheddine[2]

[1]Department of Biology and Cellular Physiology, University of Saad Dahlab, Blida 1, Animal Ecobiology Laboratory, 09000 Blida, Algeria
[2]Department of Zoology, National Agronomic School, El Harrach, 16200 Algiers, Algeria
[*]Corresponding author, e-mail: souarab2002@yahoo.fr

ABSTRACT This work focuses on the study of the diet of the ant *Cataglyphis bicolor* (Fabricius, 1793) (Hymenoptera Formicidae) in the natural reserve of the Reghaïa wetland through the analysis of two nests. This study shows that Hymenoptera dominates in the trophic menu of this species at 92.7 % for Nest 1 and 87% for Nest 2, with a total of 60 species divided between 3 classes, 10 orders and 31 families. The most consumed species by *C. bicolor* is *Messor barbarus* (Linnaeus, 1767) (Hymenoptera Formicidae) with 87% (Nest 1) and 82.2% (Nest 2). In terms of biomass, a species of Coleoptera dominates either *Ophonus* sp. (B.% = 9.36 %). *Messor barbarus* dominates in relative abundance and has only a very small part of the biomass ingested (0.37%). The size of *C. bicolor* prey species is between 1 and 24 mm for Nest 1 and 1 and 30 mm for Nest 2.

KEY WORDS Diet; Relative biomass; Size class; *Cataglyphis bicolor*; Reghaïa wetland reserve; Algeria.

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INTRODUCTION

Cataglyphis bicolor (Fabricius, 1793) (Hymenoptera Formicidae) is an ant predator of strictly diurnal activity (Cagniant, 1973). Its diet consists mainly of dead insects, often other Formicidae: *Messor* Forel, 1890 and *Camponotus* Mayr, 1861, but also adults of other *Cataglyphis* Förster, 1850. Moreover, it feeds on various live prey, like caterpillars and other larvae, adult beetles, small arachnids, and sweet vegetable liquids (Cagniant, 2009).

According to Cagniant (2009), *Cataglyphis* are found in North Africa from the seashore to 2800 m at Hoggar. These ants nest in open places, large clearings, mountain pastures, steppes, wastelands, and unpaved streets. They appear to be anthropogenic and their expansion has been favored by human activities. Colonies are established in flat areas, avoiding steep slopes or rock scree. In *C. bicolor*, the large-sized workers go out to supply, while the small ones usually stay at the nest to care for the brood (Cagniant, 2009).

Several authors have studied the ecology and behavior of this ant: Bernard (1948), Grassé (1951), Délye (1957), Bernard (1968), Cagniant (1973), Délye (1974), Hölldobler & Wilson (1993), Heusser & Wehner (2002), and Dietrich & Wehner (2003).

In Algeria, Molinari (1989), Baouane (2002), and Ouarab et al. (2006, 2010) examined the feeding of this ant in the Reghaïa wetland. Elsewhere, other authors have examined the trophic menu of *C. bicolor*, notably Sekour (2002) in Mergueb,

Talmat (2002) in the region of Tigzirt and Iflissen, Ziada (2006) and Ziada & Doumandji (2008) in the region of Guelma, and Moulai et al. (2006a, b) in the region of Bejaia. *Cataglyphis bicolor* itself plays the role of prey.

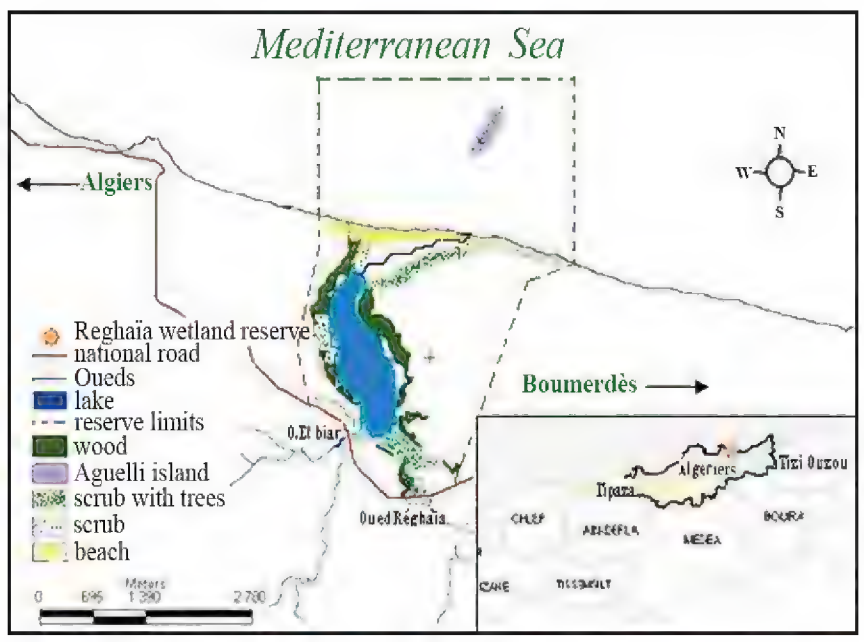
The aim of this work is to study trophic behavior and to address the quantitative aspect of *C. bicolor* in relation to the size and weight of the prey present in its diet.

MATERIAL AND METHODS

The Reghaïa wetland has been a Ramsar site since 2003 (36°46' to 36°47'N, 3°19' to 3°20'E, Fig. 1) and a nature reserve since 2016. It is located in the eastern part of the Mitidja plain, on the edge of the Mediterranean Sea. It is bounded on the north by the Mediterranean Sea, on the west by Oued El Hamiz, on the south by the eastern part of Mitidja and on the east by Oued Boudouaou and by the first hills that announce the Kabyle massif (Mutin, 1977).

As the climate of the study area is tempered by the proximity of the Mediterranean Sea, its climate belongs to the subhumid bioclimatic stage in warm winter. Rainfall fluctuates from year to year between 200 and 800 mm, and reached 760.6 mm in 2004. The average annual temperature is 18.0 °C.

Arthropod body fragments were collected around the entrance to the nest of *C. bicolor*. They were put in paper bags bearing information on the date and place of harvest. Sampling was carried out during the months of July and September 2003.



Study area: Reghaïa wetland reserve (Algeria).

Sometimes, the operator could not collect all the remains of the fragments and was forced to dig at the entrance of the nest to recover soil containing the sclerotinized fragments.

In the trophic regime of the ant *C. bicolor*, the recognition of arthropods was carried out in the entomology laboratory of the El Harrach, National Agronomic School. The systematic analysis of the insects was carried out in a progressive way. The determination was made by observations with a binocular loupe whose magnification is 10x1.6. Taxonomic research was carried, usually, up to the family or genus and rarely up to the species for insects, and only up to order or class for other arthropods. Among the Arthropods, the Aranea are recognizable by their jaw legs, cephalothorax, very hairy legs and their eyes. Crustacea Isopoda and Diplopoda are sometimes difficult to discern. Formicidae are identifiable by their head and thorax.

From a fragment, the estimate of the size of each species (E.T.P.) was carried out as follows. The length of the sclerotinized part is measured using a small 2x10 mm graph paper tab. Knowing the proportions of the Arthropoda bodies, the size of the sample is estimated from the fragment present. There is a certain margin of error that can be reduced by comparison with the species of the insectarium of the National Agricultural School of El Harrach. For Orthoptera and Heteroptera, the head is 1/6th of the whole body, 1/2 for the abdomen and 1/3 for the thorax. These measures can be variable, especially when it comes to polymorphic species such as the ants *Messor barbarus*, *Camponotus* sp. and *Pheidole pallidula*.

The results were analyzed using different ecological indices of composition, such as total wealth, or the number of species present in all *C. bicolor* nests (Blondel, 1969). The relative abundance corresponds to the percentage of individuals of a species taken into consideration in relation to the total of all species combined (Dajoz, 1971; Bigot & Bodot, 1973); percentage of biomass corresponds to the percentage of the weight of individuals of a species (Pi) relative to the total weight of the whole prey (P) (Vivien, 1973).

RESULTS

Relative to the contents of two nests, the trophic

diet of *C. bicolor* includes 60 prey species (Table 1). These species are divided into 3 classes, 10 orders and 31 families. There were 439 prey for the first nest and 399 prey species for the second nest. These are part of 10 orders of which one of them is well represented (Hymenoptera with 92.7% in Nest 1 and 87% in Nest 2). *Messor barbarus* is present with 87% in Nest 1 and 82.2% in Nest 2.

In the trophic diet of *C. bicolor*, the highest relative biomass value is for *Ophonus* sp. (B.% = 9.36%) (Table 1), but, in terms of relative abundance, this species is poorly noted in the diet of *C. bicolor*. Then comes that of an undetermined species of Oniscidae that has 31 individuals (B.% = 9.36%) and *Aiolopus strepens* (Latreille, 1804) in third place (B.% = 8.61%). Other species participate with low rates.

The size classes of the species found in the diet of *C. bicolor* in the Reghaïa wetland range between 1 and 24 mm for Nest 1 and 1 and 30 mm for Nest 2 (Fig. 2). The most abundant size classes are 5 mm (AR% = 20%), 6 mm (AR% = 8.9%), and 8 mm (AR% = 13.3%) for Nest 1. Class of 5 mm is represented by *Sinoxylon* sp. and *Ophthalmicus* sp., and that of 8 mm by *Crypticus obesus* and *Larinus* sp. 2. For Nest 2, the most represented size classes are 4 mm (AR% = 10.8%), 5 mm (AR% = 10.8%), 6 mm (AR% = 10.8 %), and 8 mm (AR% = 18.9%). The size class of 8 mm corresponds to *Cassida ferruginea*, *Carpocoris* sp., and *Otiorrhynchus* sp. (Fig. 3).

DISCUSSION

The study of the diet of the ants *C. bicolor* in the Reghaïa wetland shows that the most abundant prey species found in the nests of C. bicolor are Formicidae (Hymenoptera), particularly *Messor barbarus* (first nest AR.% = 87.0%, second nest AR% = 82.2%). Bernard (1951) wrote that *C. bicolor* hunts alone or in small groups and attacks preferably ants of the genus *Messor*. The present results are consistent with those found by Bernard (1951) and Ouarab et al. (2006), which indicate that Formicidae dominate in the *C. bicolor* diet. These authors mention *Tapinoma nigerrimum* with 33.4% for Nest 1 and 68.8% for Nest 2 around Reghaïa marsh. *Messor barbarus* (19%) is dominant near Tigzirt and the Mergueb reserve (46.3% in Nest 1 and 62.5% in Nest 2). In the last station cited, Sekour et al. (2007) report that Formicidae are first with *Messor barbarus* (56.2%). Similarly, the high frequency of *Messor barbarus* in *C. bicolor* diet is already mentioned by Moulai et al. (2006a) near Bejaia (49.8% in a wasteland and 34.3% in a scrubland). Filali & Doumandji (2008) note the contribution of the harvesting ant in the diet of *C. bicolor* with a rate of 37.4%. Djennoune et al. (2018) in two localities of Kabylie in Algeria presented the biochemical composition of *Messor* sp. The results found show that this species is very rich in proteins (72.74%), low in lipids (5.05%) and no carbs. According to these same authors (Filali & Doumandj, 2008), the total energy value of these three biochemical components in *Messor* sp. equals 336.41 kcal / % dry matter.

In the trophic diet of *C. bicolor*, the highest relative biomass value is noted for *Ophonus* sp. (B.% = 9.36%). Ziada (2006) reports that *C. bicolor* itself as prey has the highest biomass rate (B.% = 12.4%). In our experience, the same *C. bicolor* is totally absent from *C. bicolor*'s menu near the Marsh of Reghaïa. In Guayaza, Guerzou (2009) reports that an indeterminate species of lizard (Lacertidae sp. ind.) is dominant with 32.5%. The following authors, who treated the diet of *C. bicolor,* did not exploit their results by relative biomass (Barech, 1999; Sekour, 2002; Ouarab et al., 2006, 2010; Moulai et al., 2006a, 2006b; Filali & Doumandji, 2008). Ziada (2006) and Guerzou (2009), on the contrary, were interested in this aspect.

The size classes of the species found in the diet of *C. bicolor* in the Reghaïa wetland range from 1 to 24 mm for Nest 1 and from 1 to 30 mm for Nest 2. Filali & Doumandji (2008) near Azzaba find values that vary between 1 and 45 mm. Moulai et al. (2006a) report larger sizes of prey of *C. bicolor* at a fallow land near Bejaia ranging from 3 to 73 mm, in a garrigue of the same sizes comparable to those found in this study. Also Ziada (2006) finds very large sizes between 1 and 100 mm. In the vicinity of Reghaïa marsh, the most common size class is 5 mm (A.R.% = 20%) for Nest 1 and 8 mm for Nest 2 (A.R.% = 18.9%). Ziada (2006), near Guelma, mentions that the most ingested prey (27%) by *C. bicolor* are those of sizes between 4.5 and 5.4 mm. Filali & Doumandji (2008) in Azzaba

			Nest 1		Nest 2		B %
Ordres	**Families**	**Species**	**ni.**	**AR%**	**ni.**	**AR%**	
Aranea	--------	Aranea sp. 1	0	0	1	0.25	0.94
Ricinuleida	--------	Ricinuleida sp. 1	0	0	1	0.25	0.94
Isopoda	--------	Isopoda sp. 1	0	0	31	7.77	**9.36**
Orthoptera	Acrididae	*Aiolopus strepens*	0	0	1	0.25	**8.61**
		Pezotettix giornai	0	0	1	0.25	2.62
		Acrididae sp. 1	1	0.23	0	0	7.49
	Gryllidae	Gryllidae sp. 1	1	0.23	0	0	5.62
Dermaptera	Dermaptera	Dermaptera sp. 1	0	0	1	0.25	5.62
Heteroptera	Scutelleridae	*Ancyrosoma albolineata*	0	0	1	0.25	0.37
	Reduviidae	Reduviidae sp. 1	1	0.23	0	0	0.94
	Pentatomidae	*Carpocoris* sp.	1	0.23	0	0	1.69
		Sehirus sp.	0	0	1	0.25	0.56
		Sciocoris sp.	0	0	1	0.25	0.28
	Lygaeidae	*Ophthalmicus* sp.	1	0.23	0	0	0.56
		Lygaeidae sp. 1	0	0	1	0.25	0.56
		Lygaeidae sp. 2	0	0	1	0.25	0.37
Homoptera	Jassidae	Jassidae sp. 1	1	0.23	0	0	0.19
		Jassidae sp. 2	1	0.23	0	0	0.19
	Fulgoridae	Fulgoridae sp. 1	1	0.23	0	0	0.37
Coleoptera	Coleoptera	Coleoptera sp. 1	0	0	1	0.25	5.62
	Harpalidae	*Harpalus fulvus*	0	0	1	0.25	7.49
		Carterus sp.	0	0	2	0.5	5.62
		Ophonus sp.	0	0	2	0.5	**9.36**
	Elateridae	Elateridae sp. 1	0	0	1	0.25	0.94
	Tenebrionidae	*Crypticus obesus*	2	0.46	1	0.25	1.31
		Tenebrionidae sp. 1	1	0.23	0	0	1.87
		Pachychila sp.	0	0	1	0.25	1.87
	Bostrychidae	Bostrychidae sp. 1	1	0.23	0	0	1.12
	Chrysomelidae	*Cassida ferruginea*	1	0.23	0	0	0.37
		Chrysomelidae sp. 1	1	0.23	0	0	0.09
	Bruchidae	*Bruchidius* sp.	1	0.23	0	0	0.19
		Bruchidae sp. 1	1	0.23	0	0	0.19
		Sinoxylon sp.	1	0.23	0	0	0.75
	Curculionidae	*Larinus* sp. 1	1	0.23	1	0.25	1.69
		Larinus sp. 2	1	0.23	0	0	1.50
		Otiorhynchus sp.	3	0.68	0	0	1.69
		Curculionidae sp. 1	1	0.23	0	0	0.09
		Curculionidae sp. 2	1	0.23	0	0	0.09
		Curculionidae sp. 3	1	0.23	1	0.25	0.02
		Sitona sp.	2	0.46	0	0	1.31
		Nanophyies sp.	1	0.23	0	0	0.13

Table 1/1. Relative abundances of prey species inventoried at the entrance to the nest of *Cataglyphis bicolor*.

			Nest 1		Nest 2		B %
			ni.	AR%	ni.	AR%	
Hymenoptera	Chrysidae	*Chrysis* sp.	0	0	1	0.25	0.56
	Halictidae	*Lasioglossum* sp.	0	0	1	0.25	0.56
	Bethylidae	Bethylidae sp. 1	2	0.46	1	0.25	0.15
	Apidae	*Apis mellifera*	1	0.23	1	0.25	1.50
	Formicidae	*Messor barbara*	**382**	**87.02**	**328**	82.21	0.37
		Camponotus sp.	2	0.46	0	0	0.37
		Aphaenogaster testaceopilosa	8	1.82	6	1.5	0.06
		Pheidole pallidula	0	0	7	1.75	0.02
		Crematogaster auberti	0	0	1	0.25	0.06
		Tetramorium biskrensis	6	1.37	1	0.25	0.02
		Tapinoma nigerrimum	1	0.23	0	0	0.04
		Monomorium sp.	1	0.23	0	0	0.04
	Vespidae	Vespidae sp. 1	1	0.23	0	0	0.94
		Vespa germanica	1	0.23	0	0	1.50
	Vespoidea	Vespoidea sp. 1	1	0.23	0	0	0.94
	Syrphidae	Syrphidae sp. 1	1	0.23	0	0	0.94
Diptera	Calliphoridae	Calliphoridae sp. 1	1	0.23	0	0	0.56
	Sarcophagidae	Sarcophagidae sp. 1	1	0.23	0	0	0.56
	Trypetidae	Cyclorrhapha sp.	2	0.46	0	0	0.19
10	**31**	**60**	**439**	100	**399**	100	100

Table 1/2. Relative abundances of prey species inventoried at the entrance to the nest of *Cataglyphis bicolor*.

note that the 6 mm size species are the most consumed at 19.2%. In the Reghaïa marsh, the 24 mm classes (AR% = 2.2%, nest 1) corresponding to Gryllidae sp. indet. and 30 mm (AR% = 2.7%, Nest 2) corresponding to *Aiolopus strepens* are poorly represented. At the Guayaza station near Djelfa, Guerzou (2009) reports that the 120 mm class corresponding to Lacertidae sp. indet. (AR% = 0.45%) is also poorly reported. Similarly, Ziada (2006) points out that the class of 100 mm. corresponding to *Chalcides ocellatus* (AR% = 0.06%) is poorly reported.

CONCLUSIONS

The study of *C. bicolor* diet by the analysis of two nests in the natural reserve of the lake of Reghaïa allowed us to find a total wealth of 60 species. Relative abundance shows that *Messor barbara* is the most abundant species in this ant's diet for both nests with 87% in Nest 1 and 82.2% in Nest 2.

In terms of biomass, a species of *Ophonus* sp. (B.% = 9.36%) is prevalent. Yet, in terms of relative abundance, the latter species is poorly noted in the diet of this ant. In contrast, the species *Messor barbarue*, which dominates the other species in terms of relative abundance, represents only a very small part of the biomass ingested (0.37%).

The most abundant size class is the 5 mm, represented by *Sinoxylon* sp. and *Ophthalmicus* sp. for Nest 1. For Nest 2, the most represented size class is the 8 mm (18.9%). The size class of 8 mm corresponds to *Cassida ferruginea*, *Carpocoris* sp. and *Otiorrhynchus* sp.

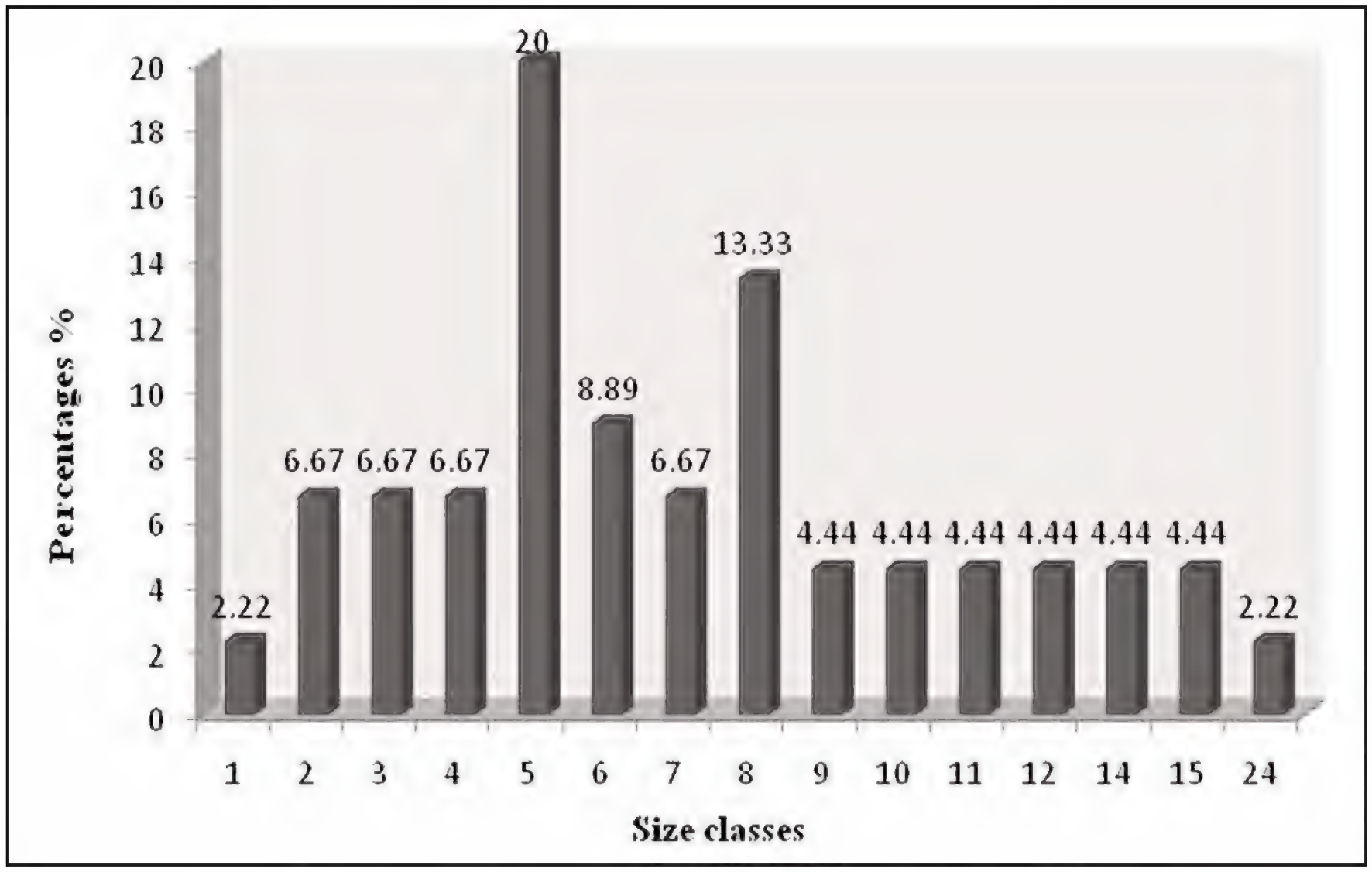


Figure 2. Size classes rate found in the *Cataglyphis bicolor* trophic menu near Reghaïa swamp in Nest 1.

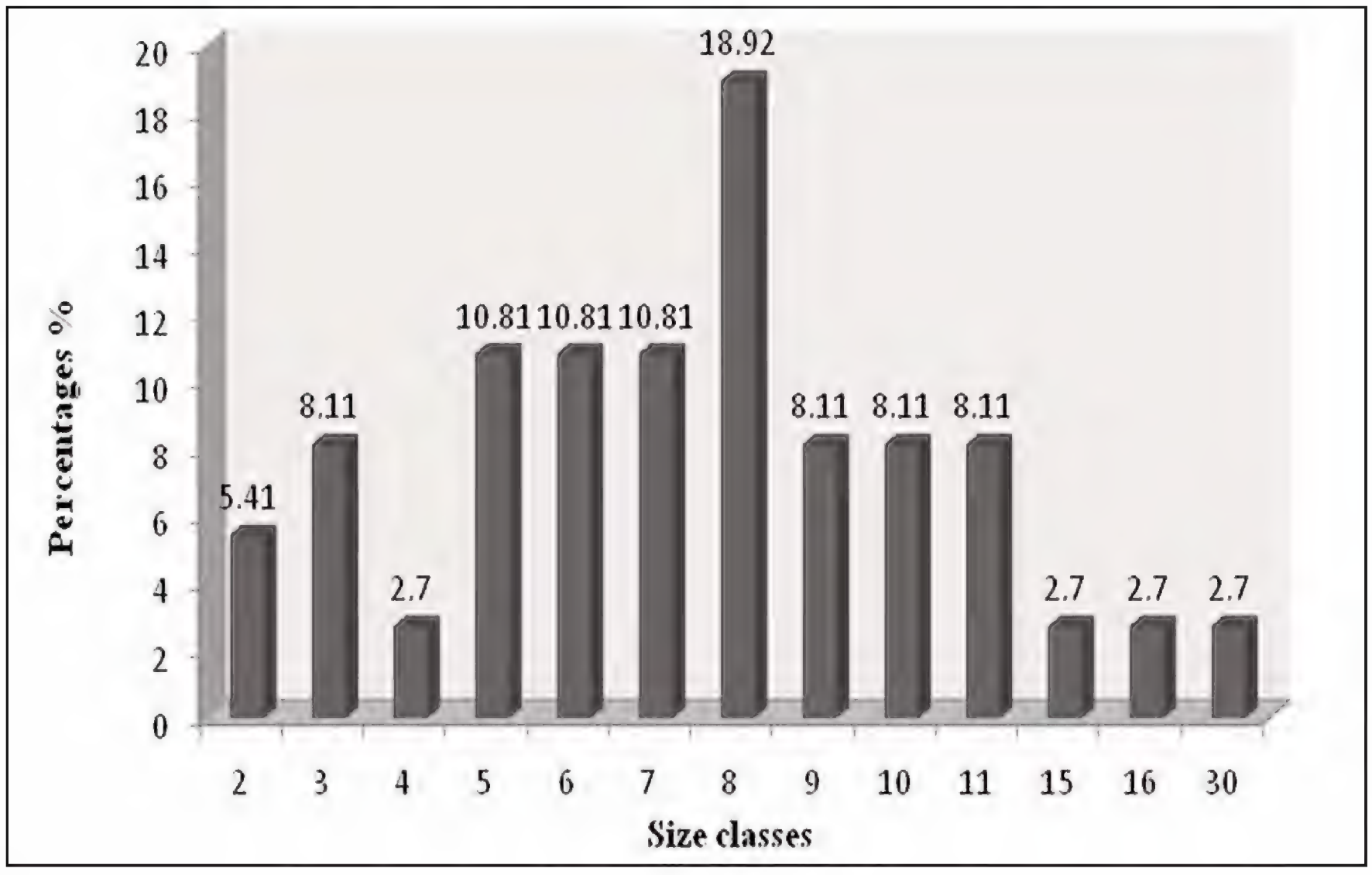


Figure 3. Size classes rates found in the trophic menu of *Cataglyphis bicolor* near Reghaïa swamp in Nest 2.

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Fishing of Norway lobster *Nephrops norvegicus* (Linnaeus, 1758) (Decapoda Nephropidae) in Algerian western waters

Djamel Bekrattou, Salim Mouffok*, Noureddine Benaissa & Mohammed Bouderbala

Laboratoire Réseau de Surveillance Environnementale, Département de Biologie, Faculté des Sciences de la Nature et de la Vie, Université Oran 1, BP 1524 El Menaouar, Algeria

*Corresponding author, e-mail: halieutsalim@yahoo.fr

ABSTRACT A frequently occurring species with high market value in Algeria, the Norway lobster *Nephrops norvegicus* (Linnaeus, 1758) (Decapoda Nephropidae) has attracted the interest of many professional fishermen. Fishery for this species has been growing rapidly in recent years. In this work, we collected data on the eco-biology, production, and monitoring of fishing effort and calculated yields. Our main objective is to provide an introduction to the fishing activity of this crustacean decapod in western Algeria, to provide a database for further studies of the lobster stock, and to contribute to the improvement and development of lobster fishery in Algeria.

KEY WORDS Algeria; capture; effort; eco-biology; *Nephrops norvegicus*; performance.

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INTRODUCTION

In Algeria, due to the absence of any form of crustacean farming, the total shrimp production corresponds to over 90% fishing. Three shrimp species of high commercial value are caught that, in order of abundance, are: *Aristeus antennatus* (Risso, 1816) (Aristeidae), *Parapenaeus longirostris* (Lucas, 1846), and *Penaeus kerathurus* (Forskål, 1775) (Penaeidae).

Due to the considerable economic value, some crustaceans have attracted the interest of many professional fishermen. This is the case for the Norway lobster *Nephrops norvegicus* (Linnaeus, 1758) (Decapoda Nephropidae) which leads a demersal life, living on sandy mud bottoms (Sarda & Aguzzi, 2012). Its bathymetric distribution is wide, ranging from 15 m to 800 m (Farmer, 1972) but, typically, from 180 to 500 m (Abello & Sarda, 1982; Dintheer, 1982; Orsi Relini & Relini, 1985).

On the biology and fishing of *N. norvegicus*, several studies have been published for the Mediterranean Sea in Spain by Sarda (1998), Sarda et al., (1998), and Aguzzi et al. (2004, 2009a), in France by Fontaine & Warluzel (1969), Morizur et al. (1981), Morizur (1983), and Macher et al. (2008), and in Greece by Castro et al. (1998).

In Algeria, *N. norvegicus* is abundant in the extreme West (from Ghazaouet to Bouzedjar) and a first estimate made in 1982 on the level of this marine zone reveals a high biomass (ISTPM, 1982). In this coastal area of western Algeria, this crustacean is found on the continental shelf edge between 180 and 550 m depth, with a higher density between 280 and 400 m (CGPM/GFCM, 1982; Massuti et al., 2003). However, this Arthropod becomes gradually scarce as we move from Habibas Islands (western Algeria) towards the eastern country coast.

We tried to get as much information as possible on the eco-biology and fisheries of *N. norvegicus*

in order to exploit the results as a data basis for future studies and contribute to the improvement and the management of these crustaceans fisheries in Algeria.

MATERIAL AND METHODS

Study area

In Algeria, the lobster is caught in the western region of the country, which extends on approximately 5000 m² all along the 80 km of coastline limited to the West and the East respectively by the meridian lines 2°00'E and 2°30'E and 2°00 E and 2°30'E and North by the parallel 35°20'N and 35°40'N (Fig. 1).

Sampling

Twenty-one sea trips have been carried out on a professional trawler operating in a regular way from June 2011 to April 2012 on our study area (Cape Noe until Habibas Islands; Fig. 1) with 617 specimens gathered.

Data collection on fishing for this lobster is based mainly from surveys and personal investigations in the field, obtained from personal commercial fisheries statistics, and also gathered from the concerned management and fishing resources services (DPRH). The information on the capture sites and the sorting characteristics, as well as other data on the lobster fishery, were collected from some skippers. These data provided additional information to those presented in Table 1 on the various areas restricted for the Norway lobster fishing activity and bathymetric limits (Table 1). The preliminary treatment of collected specimens were carried aboard a trawler. After sorting by sex, each individual was measured using a caliper and weighed by a precision balance. For females, the ovaries stages maturity was determined by macroscopic observation according to the Farmer scale (1972, 1975). We adopted three gonadic stages (Table 2).

We then analyzed the various data obtained through different models and equations below: the overall sex ratio, the sex ratio according to size, and the sex ratio according to seasons.

It has been calculated a χ^2 heterogeneity test, the risk of a degree of freedom and $p < 0.05$ significance, using the STATISTICA Software (StatSoft Inc., 2001) to determine whether the predominance of each sex in each class size and during all sampling months are significant or not.

The length at first maturity (L 50) is the length at which 50% of females are mature (Fontaine & Warluzel, 1969; Conand, 1977). To provide details on the reproductive cycle and the lobster laying, L 50 was calculated as follows:

$$L_{50} = \frac{S_1}{S_2}$$

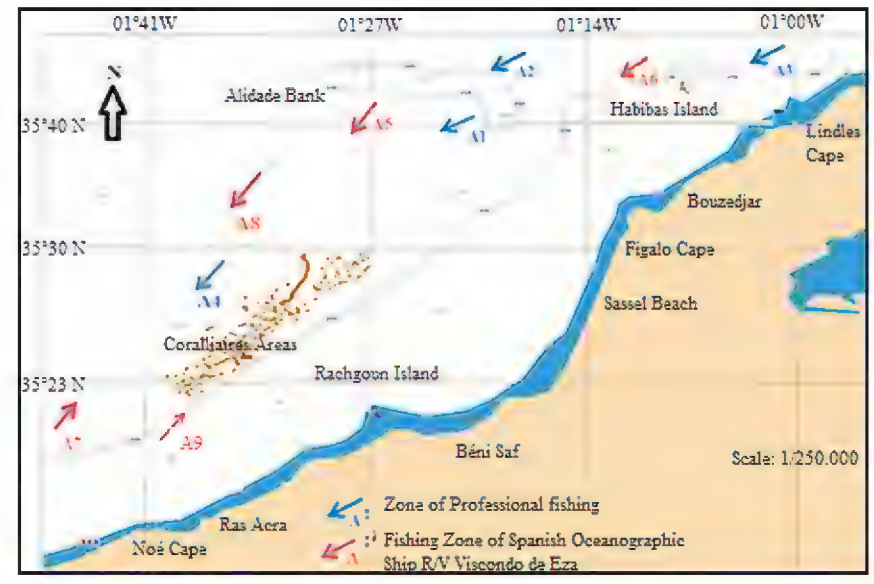

Figure 1. The *Nephrops norvegicus* geographical distribution in western Algeria with the fishing areas.

A1	35° 41' 000'' N	01° 21' 600''W	336	357
A 2	35° 41'565'' N	01° 21' 770''W	362	383
A 3	35° 41'000'' N	01° 22' 560''W	430	455
A 4	35°47' 107'' N	01° 15'967'' W	330	463
A5	35° 45' 165'' N	01° 19'461'' W	626	650
A6	35° 47' 107'' N	01° 15'967'' W	530	863
A7	35° 30' 917'' N	01° 38'692'' W	376	380
A8	35° 37' 820'' N	01° 37'274'' W	441	454
A9	35° 22' 025'' N	01° 49'970'' W	321	359
A10	35° 40' 113'' N	01° 28'464'' W	404	419

Table 1. Fishing areas for *Nephrops norvegicus* in the bay of Beni Saf (western Algeria).

Stage	ovarian Color	Other characteristics
1	White	- Threadlike(filiform) ovaries, well separated
2	Pale green	- Ovaries having developed lateral wings - Visible oocytes - Vitellogenesis
3	White and green mottled	- Ovaries during shrinkage - Oocytes being resorbed

Table 2. Summary outline of maturity stages applied to *Nephrops norvegicus* females and the equivalent macroscopic characteristics.

Growth study

The objective of this part is to determine the characteristic of living organisms, such as population size structure, growth and age of *N. norvegicus* in the targeted area of this study. There are several mathematical models to express the growth in crustaceans. A detailed review was made by Beverton & Holt (1957), Ursin (1967), Gulland (1983), Sparre & Venema (1996) and Pauly & Moreau (1997). However, the most common model is that of Von Bertalanffy (1938):

$$Lt = L\infty\left[1 - e^{-k(t-t_o)}\right]$$

L∞ is the theoretical maximum height (in mm), Lt is the size (in mm) at age t, while k is the growth coefficient.

For the assessment of these parameters, the program LFDA (Kirkwood et al., 2001)was applied to monthly catches body length using ELEFAN method. As the calculations of k and L∞ growth are correlated, we will determine Ø using the formula of Pauly & Munro (1984):

$$\Phi = 2.1\log L_\infty + k$$

Fleet and fishing effort

To identify the best fishery (fleets and fishing effort), we consulted archives at the Fisheries and Fish Resources Department (DPRH) and two fishing antennas at both Bouzedjar and Beni Saf fishing ports located in our study area (Fig. 1).

The data collected was used to get catches per unit effort equal to the fishing effort split by the boats number or E = weight in ton/day.

In addition, daily monitoring (personal observations of the trawler landings) was used to calculate the standardized CPUE.

Associated fauna

The study of the associated fauna allowed, first, to make an inventory and to know the captured species and, secondly, to determine the species composition and calculate their relative abundance which is equal to the number of the individual species on the total number of all species in percentage.

RESULTS

According to Kartas & Quignard (1984), the sex ratio is one of the parameters that helps, within a certain limit, the reproductive capacity of species in their natural environments. In other words, this index represents the abundance of one sex compared to another.

In our sample of 617 Norway lobsters, the sex of each individual has been determined (431 males and 186 females). The total sex ratio is 69.85%, with a total femininity rate of 30.15% clearly indicating a sex-ratio in favor of males. From the populations and from females and males percentages in *N. norvegicus* by size class, we illustrate the size abundance curves in figure 2. Figure 3 represents graphically the monthly variations of sex ratio; we noted that the males percentage remains quite dominant during the year.

Based on closer examination of the ovaries structure on a yearly cycle (June 2011-April 2012), we can say that the species spawning period studied in Beni Saf area takes place from November to April with a maximum phase of gonads maturation in March (Fig. 4).

The conclusion that emerges from figure 4 is that the size at first maturity is relatively variable depending on the geographical zone (Table 3), according to Cartes et al. (1993).

The analysis focuses on the distribution of the total sampled catches during the 11 months of work (June 2011 - April 2012). The LFDA Software (subroutine ELEFAN) (Kirkwood et al., 2001) was used for the calculation of the growth parameters values. The Tables 4 and 5 gives the values of L∞, K and t0 estimated for the target species, and then replaced in the Von Bertalanffy equation, as well as Ø calculated in the present study.

Figures 5 and 6 show the fleet evolution at the two ports: Beni Saf and Bouzedjar fishing with bottom trawls over a period from 2002 to 2012. We noticed from the two previous figures that the trawlers number during this period of 10 years of operation has increased from 11 to 48 at the Bouzedjar port. However, and for the same period in the Beni Saf port, the number fell from 39 to 36: the reduction is due to an operational fleet transfer of 3 trawlers from Beni Saf to Bouzedjar port.

Annual landings from 2007 to 2012 (Fig. 7) and lobster catch per unit effort (CPUE) (Fig. 8) for

fishing with bottom trawling increased from 2 to 24.5 tons, respectively, and from 0.4 to 4.1 tons per boat every year in the respective way. Furthermore, the average standardized CPUE for the port of Beni Saf showed a similar tendency, with higher values in summer and autumn.

Despite the imperfection of quantitative appreciations that can be drawn from a study of associated fauna (Fig. 9) by trawling (from a sea trip to another catch the number of individuals and the number of species are highly variable), the analysis of the results reveals that the Norway lobsters are the most abundant species, especially in the median area of the continental shelf between a depth of 250 and 400 meters. The captured fish in these bottoms relates for the most part to the Gadidae family: the most common species are *Merluccius merluccius* (Linnaeus, 1758), followed by *Phycis blennoides* (Brünnich, 1768). The most common cephalopod being the *Octopus vulgaris* (Linnaeus, 1758) and, for crustacean fauna, the *Parapenaeus longirostris*. Lastly, only commercial species smaller than the stated size, as the dogfish *Scyliorhinus canicula* (Linnaeus, 1758), remain.

DISCUSSION AND CONCLUSIONS

Our study was conducted over a period of 11 months (12 June 2011–11 April 2012) with a total sample of 617 Norway lobster specimens. We noted a difference in the sex ratio in favor of males during the sampling period (total male proportion = 69.85%, females = 30.15%), with males being significantly more frequent than females and from size Lc= 47 mm we found only males. This could result in a slightly faster growth for males. Charuau (1978) formulated the hypothesis that female growth would be slowed due to less frequent molts. Another explanation of the difference in the sex ratio in favor of males would be due to the low proportion of females in the catch, because they are less active and often hide in burrows (Jukic, 1971; Froglia & Gramitto, 1981; Orsi Relini et al., 1998; Ungaro et al., 1999).

For the determination of the reproductive cycle and the laying period, based on the ovaries structure observation over a complete cycle (June 2011–April 2012), we can say that the *N. norvegicus* spawning period in Beni-Saf area occurs from November to April with the maximum gonads maturation phase in March. Our results are practically similar to those obtained by other cited authors. These clearly define the spawning period in the Spring and early Summer. This situation is common to the Mediterranean shore (Karlovac, 1953; Morizur et al., 1978; Froglia & Gramitto, 1979, 1981; Sarda, 1985; Sarda & Cros, 1984; Sarda, 1983a, b, 1985, 1991; Froglia & Gramitto, 1988; Orsi Relini & Relini, 1989; Sarda & Valladares, 1990; Sarda & Lleonart, 1993; Mc Quaid et al., 2006; Morello et al., 2009).

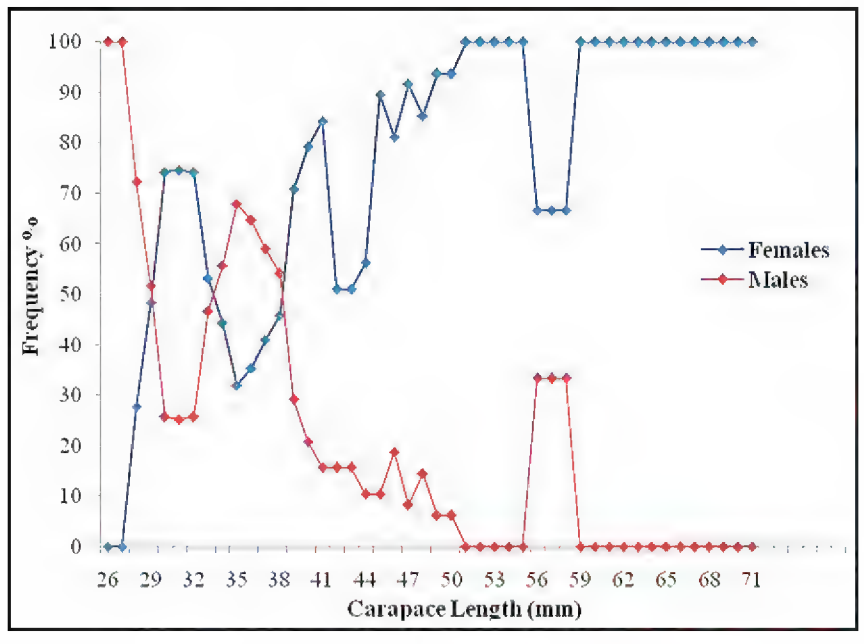

Figure 2. The *Nephrops norvegicus* males and females abundance curve vs size. The results of χ^2 test highlight the predominance of the sexes according to the fishing months (* $p<0.05$ significance).

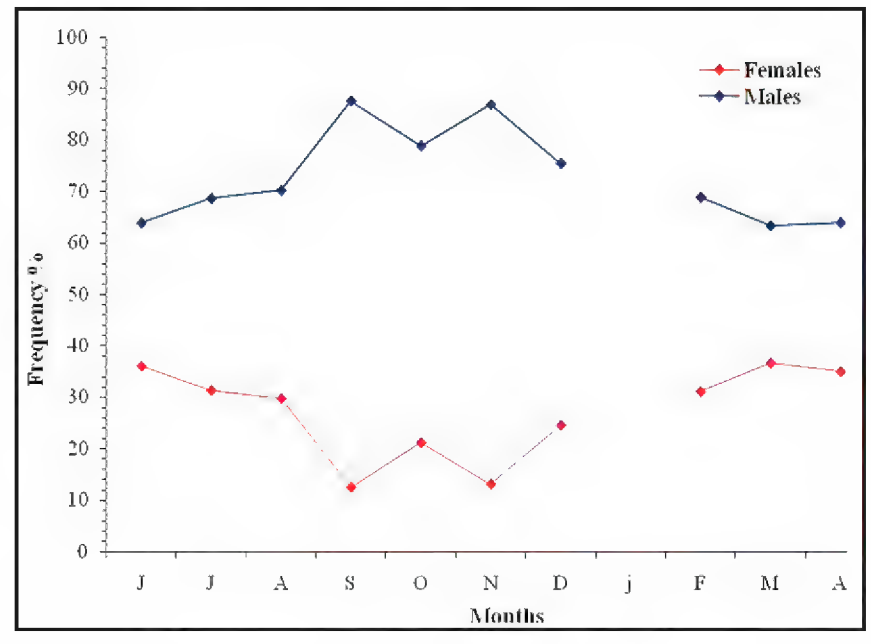

Figure 3. The *Nephrops norvegicus* males and females abundance curve vs size. The results of χ^2 test highlight the predominance of the sexes according to the fishing months (* $p<0.05$ significance).

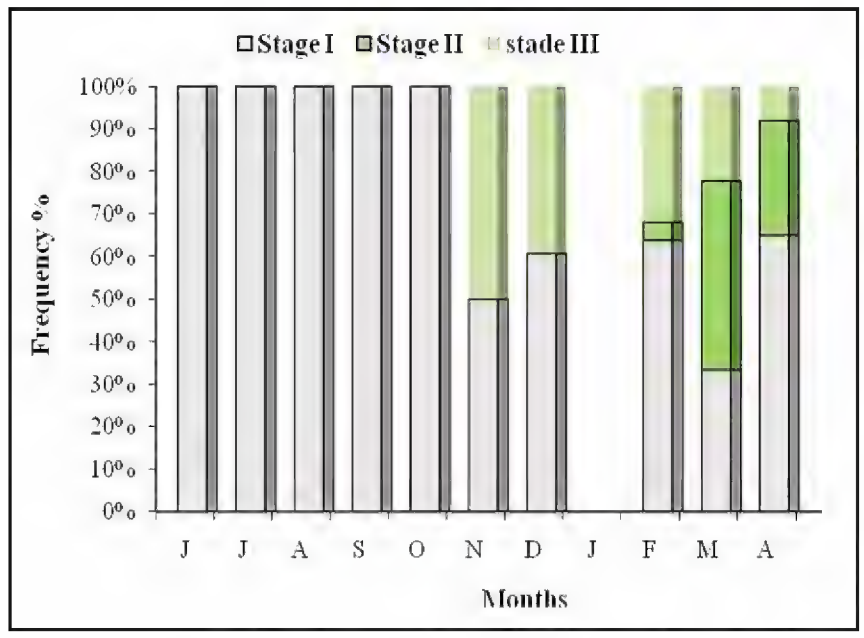

Figure 4. Percentages of different stages of sexual maturity in *Nephrops norvegicus* females.

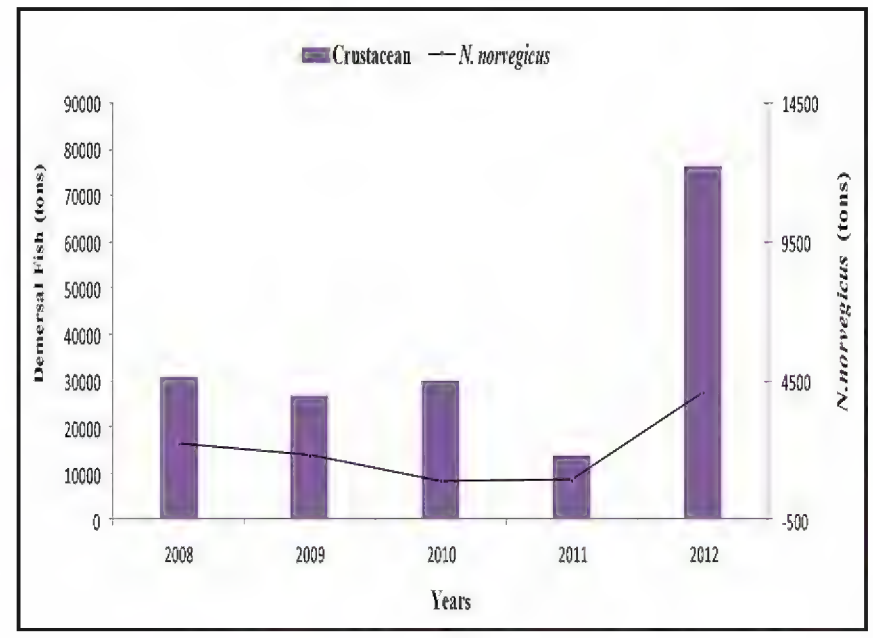

Figure 7. Annual unloadings of demersal fish and lobster *Nephrops norvegicus*.

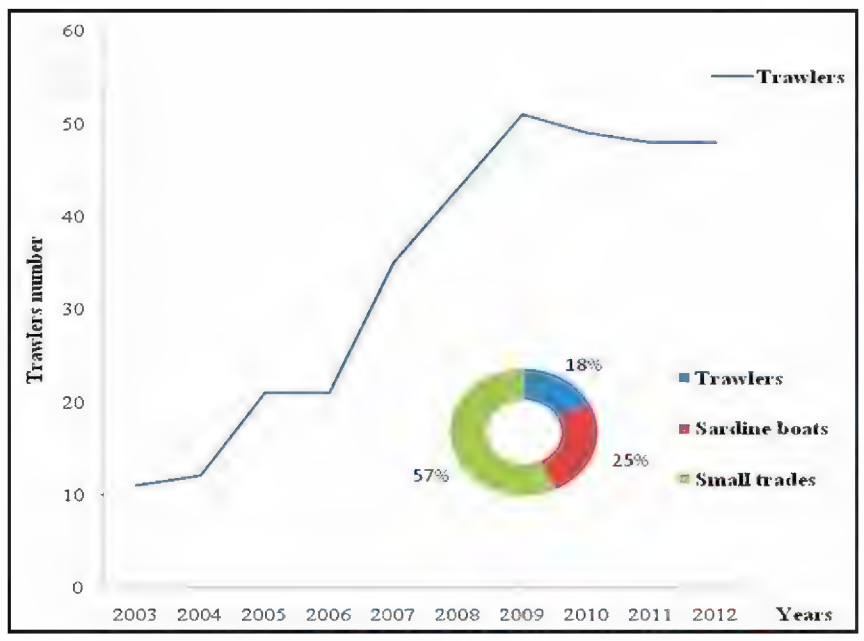

Figure 5. Annual evaluation of the trawlers number at Bouzedjar port.

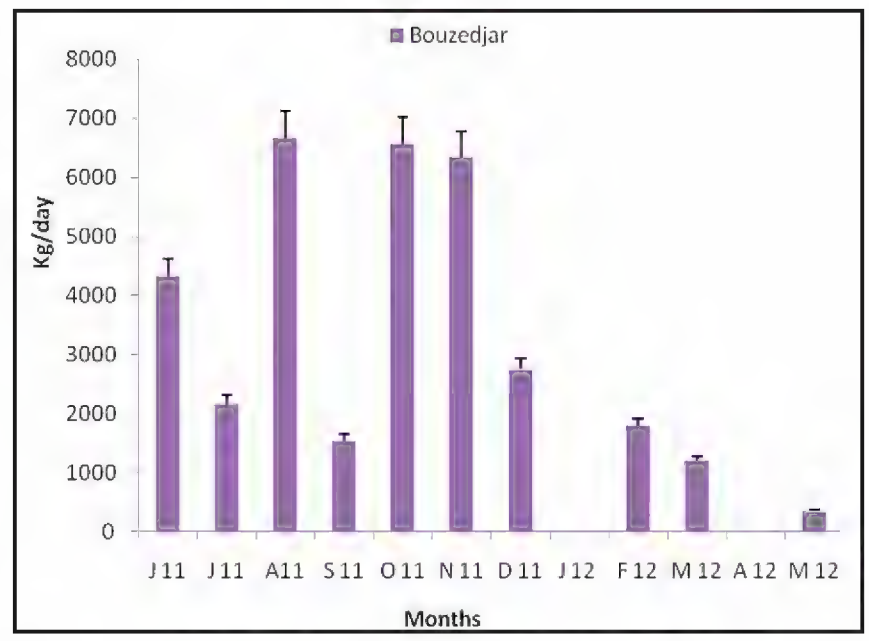

Figure 8. Monthly average of the standardized CPUE (with standard error) of Bouzedjar port.

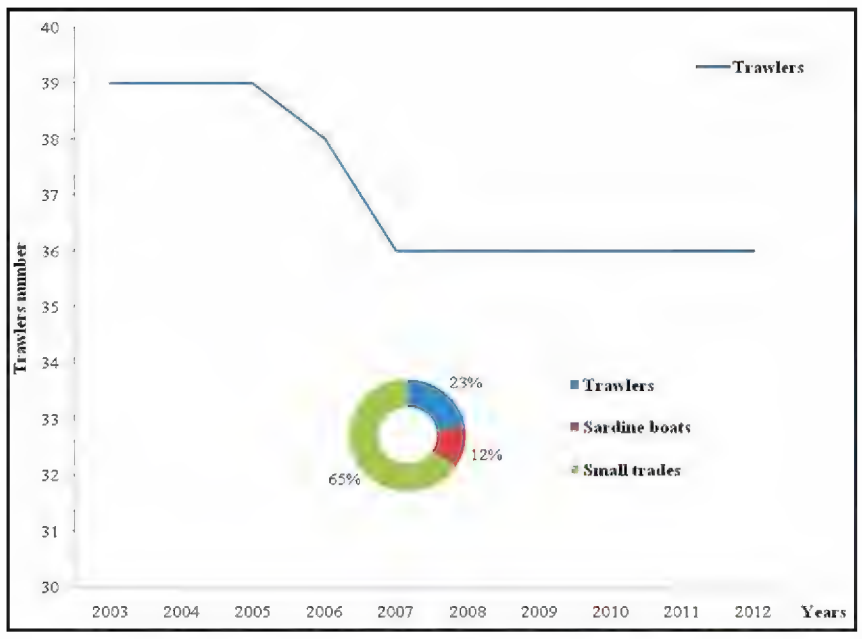

Figure 6. Annual evaluation of the trawlers number at Béni-Saf port.

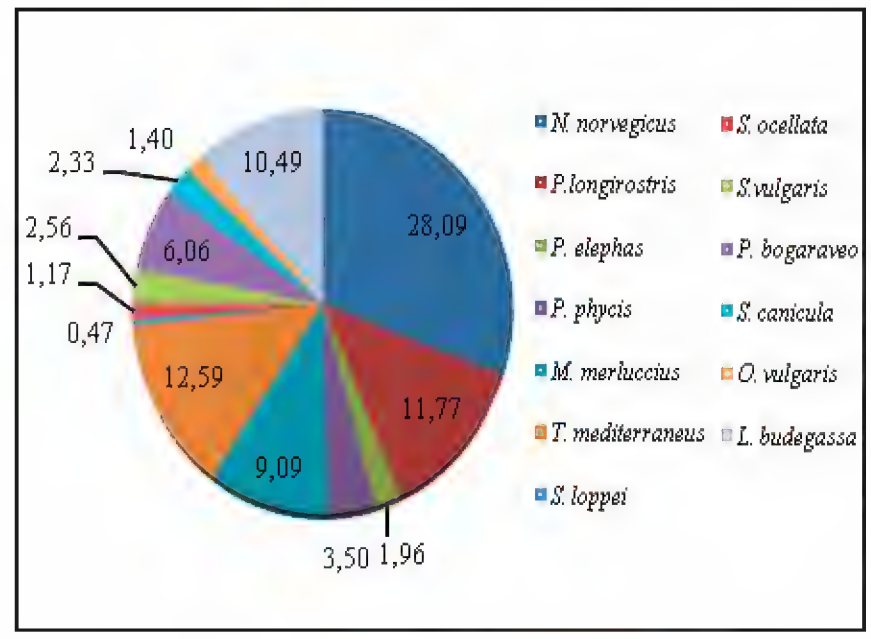

Figure 9. *Nephrops norvegicus* lobster associated fauna frequency.

In the present work, the size at first maturity (L 50) is estimated at 33 cm. These values are slightly overestimated because our samples come from commercial catches and not from experimental campaigns which operate on the whole bathymetric area. We can also add that the size at first maturity is relatively variable according to the geographical area (Cartes et al., 1993). Von Bertalanffy growth parameters are significantly different between the sexes, with higher values of the asymptotic length (L∞), growth coefficient (k), and the growth index (Φ) in favor of males. Therefore, the growth parameters estimated in the study area are in agreement with the low growth of the lobsters in the Mediterranean Sea (up to 25 to 32 years). This same model was also observed by Mytilineou et al. (1998), Sarda et al. (1998), Aguzzi et al. (2004), Cristo & Castro (2005), and Morello et al. (2008).

The results obtained in this study on the various aspects of the eco-biology of the *N. norvegicus* in Algerian western waters reveal that the life cycle of this species is similar to that observed in other Mediterranean areas.

Authors	Zone	Females (L_{50}) (mm)
Morizur, 1981	France	27 mm
Mc Quaid et *al*, 2006	Ireland	21 mm
Aguzzi et *al*, 2004	Spain	23 mm
Sarda et *al*, 1998	Spain	24 mm
Elisabetta et *al*, 2009	Italy	31 mm
Present work	Béni Saf (West Algeria)	33 mm

Table 3. Size of first sexual maturity (L50) of females in *Nephrops norvegicus*.

Sex	Males				Females			
Parameters	K	L∞	t_0	Ø	K	L∞	t_0	Ø
Results	0.16	77.50	-0.16	4.574	0.36	62.14	-0.67	4.030

Table 4. Results of growth parameters for females and males of *Nephrops norvegicus*.

Females	$Lc_t = 62.14(1-e^{-0.36\,(t+0,67)})$
Males	$Lc_t = 77.5(1-e^{-0.16\,(t+0,16)})$

Table 5. Von Bertalanffy growth Equations.

In addition, these results show that the fishing effort, implemented in the marine fishing area for Norway lobster in western Algeria, is significantly lower than that carried in other Mediterranean areas where the fishing power deployed is largely higher. In addition, the virtual absence of fishing pressure in the continental slope (depths beyond 400 m), resulted that the population of Norway lobsters at depths >400 m remains an unexploited source and a potential resource for the Algerian fishing.

Les us remind that the Norway lobster fishing is a recent activity which started only in the last decade. According to Mouffok et al. (2008), this species fishing grounds have remained untapped until the end of the last century because of their distances from the ports, weather conditions, and lack of suitable equipment (cables not sufficiently long, non-performing board equipment, poorly qualified crew, old fishing fleet, very high cost of spare parts, etc.). Fishing in the area under study was only for a particular type of shellfish: the white shrimp *Parapenaeus longirostris*.

Moreover, *N. norvegiucus* has discouraged the toughest fishermen because of its adaptation to great depths, using burrows as refuge and moving towards zones difficult to reach by trawlers (coral zones).

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Third contribution to the knowledge of Sicilian spider fauna (Arachnida Araneae)

Antonino Dentici

via Enrico Cialdini 2, 90124 Palermo, Italy; e.mail: a.dentici@virgilio.it

ABSTRACT The following work shows new or interesting data on the araneofauna of Sicily (Arachnida Araneae). Particularly, 2 genera and 7 species new for Sicily are reported and the presence of *Linyphia triangularis* (Clerck, 1757) is confirmed. Additional biological, ecological and faunistic data are provided.

KEY WORDS Araneae; Sicily; new data.

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INTRODUCTION

The arachnological researches carried out in Sicily in the last years to improve the knowledge on the araneofauna (Dentici 2017; Dentici & Amata 2018) allowed me to find new or at least interesting data that are reported in this work.

Particularly, 2 genera and 7 species new for Sicily are reported. The presence of *Linyphia triangularis* (Clerck, 1757) is confirmed for this island after the first observation by Pavesi (1868), little known in bibliography (see Pantini & Isaia, 2018).

MATERIAL AND METHODS

All samples were collected on sight under rocks or barks or in their web.

All the samples, brought to laboratory, were treated with ethyl acetate, observed with binoculars and photographed with a Nikon d90 reflex and a macro lens of 100 mm with a series of extension tubes for identification. The program Helicon focus 6 was used to merge images taken at different focal planes into single images with greater depth of field.

The specimens were stored in centrifuge tubes of different sizes, depending on the size of the sample, and were fixed in 75% ethanol and are stored in the collection of the author.

For each species literature, chorotype and distribution, biological notes and collector are indicated. The locality and/or collection site are cited in the original language (Italian).

The classification, taxonomic order, nomenclatural arrangement, and presence in the Sicilian territory follow Roberts (1995), Trotta (2004), Pantini & Isaia (2018), and World Spider Catalog (2019). Other sources have also been used for the correct identification and are, when used, signed in the species remarks.

RESULTS

Systematics

Ordo ARANEAE Clerck, 1757
Familia AGELENIDAE C.L. Koch, 1837

Genus *Tegenaria* Latreille, 1804

Tegenaria hasperi Chyzer, 1897 Figs. 1, 2

EXAMINED MATERIAL. Italy, Sicily, Palermo, Godrano, Bosco della Ficuzza, 37°51'18"N, 13°25'23"E, 05.VIII.2017, 1 female, legit R. Viviano.

DISTRIBUTION. France to Turkey, Russia (Europe).

REMARKS. The specimen was collected in the mouth of his retreat, his canvas was built in a crack in the rock and there were several other canvases like this nearby. New species for Sicily.

Familia ARANEIDAE Clerck, 1757
Genus *Leviellus* Wunderlich, 2004

Leviellus kochi (Thorell, 1870) Fig. 3

EXAMINED MATERIAL. Italy, Sicily, Palermo, Prizzi, 37°42'13.2"N 13°23'43.6"E, 30.VI.2018, 1 male, legit A. Dentici.

DISTRIBUTION. Southern Europe, North Africa, Central Asia.

REMARKS. The specimen was sampled during the night (1:30 am approximately), wandering on the bark of a tree, perhaps in search of a female. New genus and new species for Sicily.

Familia FILISTATIDAE Ausserer, 1867
Genus *Pritha* Lehtinen, 1967

Pritha pallida (Kulcynski, 1897) Fig. 4

EXAMINED MATERIAL. Italy, Sicily, Agrigento, San Biagio Platani, 37°32'34"N 13°32'39"E, 21.VII.2018, 1 female and 1 female subadult, legit R. Viviano.

DISTRIBUTION. Mediterranean.

REMARKS. The specimens were collected under rocks during daylight hours. The identification of the specimens follow Legittimo et al. (2017). New genus and new species for Sicily.

Familia GNAPHOSIDAE Pocok, 1898
Genus *Gnaphosa* Latreille, 1804

Gnaphosa dolosa Herman, 1897 Fig. 5

EXAMINED MATERIAL. Italy, Sicily, Palermo, Misilmeri, 37°59'33.4"N 13°27'51.4"E, 15.XII.2014, 1 male, legit A. Dentici.

DISTRIBUTION. Southern to Eastern Europe, Turkey, Syria, Iran, Caucasus, Russia (Europe) to Central Asia

REMARKS. Specimen collected under a wooden slab, wintering inside its silk cell. New species for Sicily.

Familia LINYPHIIDAE Blackwall, 1859
Genus *Linyphia* Latreille, 1804

Linyphia triangularis (Clerck, 1757) Fig. 6

EXAMINED MATERIAL. Italy, Sicily, Palermo, Monreale, Caculla, 38°02'59"N, 13°14'40"E, 05.IX.2018, 1 male, legit Antonino Dentici; Sicily, Palermo, Monreale, Caculla, 38°02'59.1"N, 13°14'35"E, 09.IV.2019, 1 male, legit A. Dentici.

DISTRIBUTION. Europe, Caucasus to Iran, Russia to China. Introduced to USA.

REMARKS. Specimen collected in its web. The discovery of this species, already observed by Pavesi (1878), confirms its presence (see Pantini & Isaia, 2018).

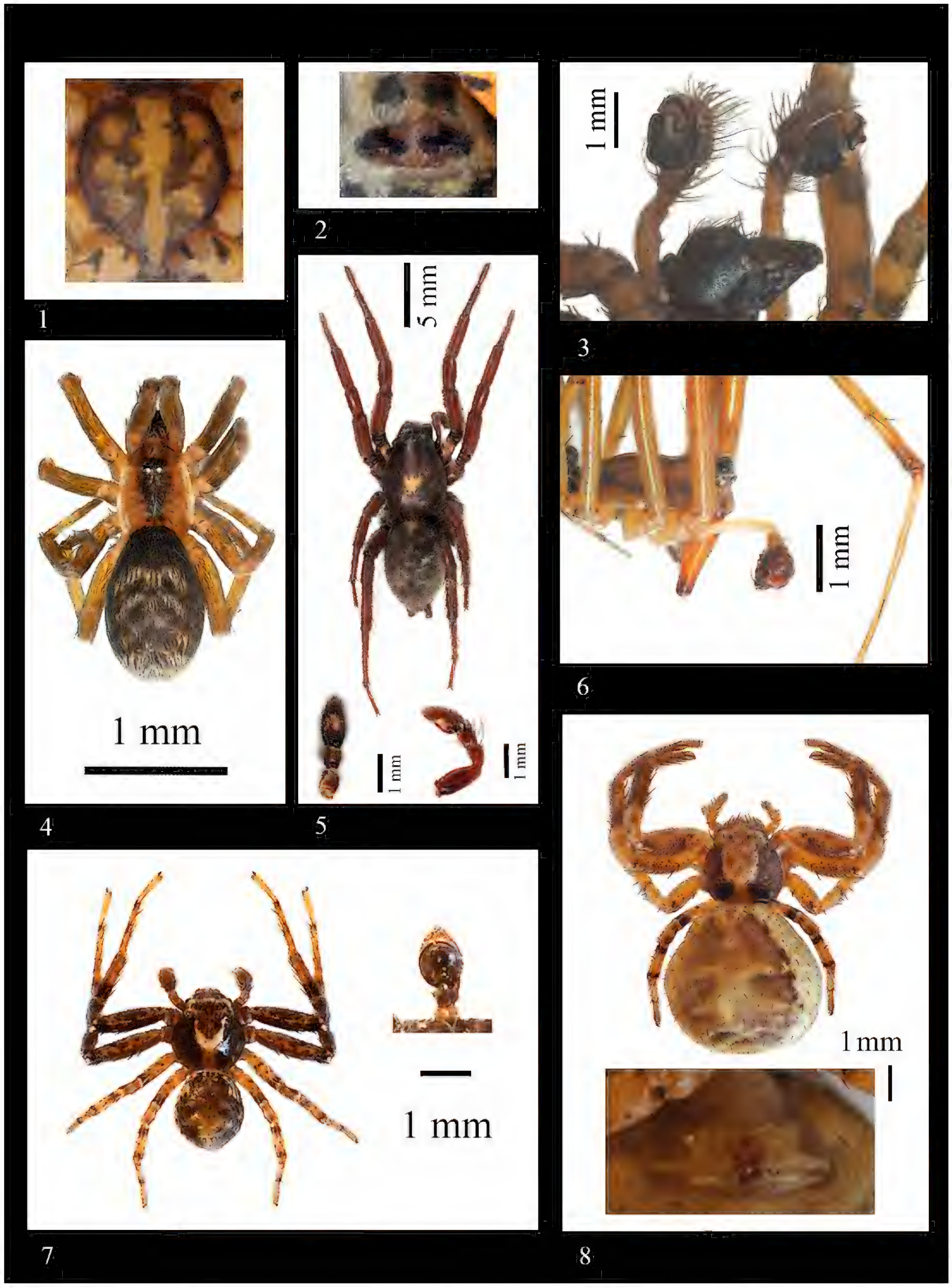
Familia TETRAGNATHIDAE Menge, 1866
Genus *Metellina* Chamberlin et Ivie, 1941

Metellina mengei (Blackwall, 1869)

EXAMINED MATERIAL. Italy, Sicily, Palermo, Giacalone, Casaboli, 38°04'12.8"N, 13°13'35.2"E, 07.IV.2019, 1 male and 1 female, legit A. Dentici.

DISTRIBUTION. Europe to Caucasus, Iran, Russia (Europe to Altai).

REMARKS. Both specimens were collected in the same web. New species for Sicily.



Figures 1, 2. *Tegenaria hasperi*: sternum (Fig. 1) and epygine (Fig. 2). Figure 3. Palpi of *Leviellus kochi*. Figure 4. *Pritha pallida*, habitus. Figure 5. *Gnaphosa dolosa*: habitus and palpi. Figure 6. Palpus of *Linyphia triangularis*. Figure 7. *Xysticus desidiosus* male: habitus and palpus. Figure 8. Idem, female.

Familia THOMISIDAE Sundevall, 1833
Genus *Xysticus* C.L. Koch, 1835

Xysticus desidiosus Simon, 1875 Figs. 7, 8

EXAMINED MATERIAL. Italy, Sicily, Palermo, Bagheria, 09.IV.2017, 1 female, legit R. Viviano; Sicily, Palermo, Monreale, Bosco di Ficuzza, 37°52'48.8"N, 13°22'43.7"E, 1 male, legit A. Dentici.

DISTRIBUTION. Europe.

REMARKS. Both specimens were found on the ground beneath rocks. New species for Sicily.

Genus *Xysticus* C.L. Koch, 1835

Xysticus nubilus Simon, 1875

EXAMINED MATERIAL. Italy, Sicily, Palermo, Monreale, Caculla, 38°03'03.7" N, 13°14'45.1"E, 22.IV.2018, 1 male, legit A. Dentici.

DISTRIBUTION. Macaronesia, Mediterranean, Georgia.

REMARKS. This species was collected under bark of *Eucalyptus*. New species for Sicily.

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Presence of the Eurasian otter *Lutra lutra* (Linnaeus, 1758) (Mammalia Mustelidae) in the Foce Sele-Tanagro Nature Reserve (Campania, Southern Italy)

Francesco Bolinesi[1], Salvatore Viglietti[2], Nicola Maio[1*] & Fabio Maria Guarino[1]

[1]Dipartimento di Biologia, Università di Napoli Federico II, Via Cinthia 26, 80126 Napoli, Italy

[2]ARPA (Agenzia Regionale Protezione Ambientale), Dipartimento Provinciale di Benevento, Via San Pasquale 36B, 82100 Benevento, Italy

[*]Corresponding author: nicola.maio@unina.it

ABSTRACT

In Italy, the Eurasian otter, *Lutra lutra* (Linnaeus, 1758) (Carnivora Mustelidae), occurs with two separated populations in the southern regions and recently it has also re-colonized the north-eastern fluvial networks. Here, we present the first photographic evidence of the Eurasian otter presence along a stretch of the Calore river (Campania region, Southern Italy), where this species was generically reported in previous study. Our findings enlighten that the Calore river network might play an important role for the conservation and expansion of this species in Campania.

KEY WORDS *Lutra lutra*; survey; Calore river; Campania; Southern Italy.

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INTRODUCTION

The Eurasian otter *Lutra lutra* (Linnaeus 1758) is a semi-aquatic mesocarnivore belonging to the family Mustelidae. This species has one of the widest distributions of all Palearctic mammals, from Ireland to China and down to Southeast Asia (Roos et al., 2015), although its distribution is very fragmented, especially in Europe, where anthropogenic factors are responsible for a low-quality habitat. In Italy, the range of the Eurasian otter appears divided into two parts: an area that falls mainly within the Molise and partly within Abruzzo regions; while the other, wider area, located south of the previous one, includes most of the regions of Campania, Basilicata, Calabria and part of Puglia (Picariello et al., 1999; Fusillo & Marcelli, 2014). Furthermore, recent findings of signs as well as road-killed individuals in north-eastern Italy suggest a possible return of the Eurasian otter in the river network of this area (Pavanello et al., 2015; http://www.units.it/lontra). However, the conservation status of this species is such to justify its inclusion in the Annexes II and IV of the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and wild fauna and flora).

The Foce Sele-Tanagro Nature Reserve (about 7284 ha) is a protected natural area in Southern Italy, established by decree of the President of the Regional Council of Campania No. 379, dated 11.06.2003. This area extends along the coastline flanking the mouth of the Sele river and in the territory surrounding the Sele, Tanagro and Calore rivers (Fig. 1), covering numerous municipalities in the provinces of Avellino and Salerno, and it is characterized by a widespread good environmental quality.

During our recent field survey of malacofauna, ichthyofauna and herpetofauna along the Calore basin river that affects the Foce Sele-Tanagro Nature Reserve (Guarino et al., in prep.), we found signs of the Eurasian otter and provided photographic evidence of its presence in this area, where it had been generically reported before (Fusillo et al., 2007; Fusillo & Marcelli, 2014). Here we report the results of the early surveys and some new records which might be useful to national and local authorities in order to ensure a local sustainable management of this endangered species.

MATERIAL AND METHODS

The study area includes about 2 km^2 (approximately 6.4 km river length and 0.3 km river surface) of the Calore river (latitude: 40°33.724'N /40°31.467 N, longitude: 15°09.276/15°10.755 E) (Fig. 1) and its associated riparian vegetation, which mainly consists of willow (*Salix* sp.), poplar (*Populus* sp.), alder (*Alnus* spp.), oaks (*Quercus cerris* L.) and reedbeds (*Phragmites* sp.) (Fig. 2). Other common species are: *Juglans regia* L., *Robinia pseudoacacia* L., *Hippocrepis emerus* (L.) Lassen.

To survey the presence of the Eurasian otter we used "observational methods" (Hoffmann et al., 2010), including direct observations and identification of signs, mainly spraints (otter faeces) and footprints.

The direct observation was carried out during the period 2016–2018, between April and July when the species is usually more active due to a combination of favorable climate and trophic availability, from early morning to dusk.

To determine the contents of the spraints, first we put them in hot water with a common detergent, then we washed through a 0.5 mm mesh sieve, air dried and lastly gently disrupted by hand. Examination of the contents was performed using a magnifying glass and Leica EZ4 Stereo Microscope (16–70 x magnification). Following Gorgadze (2013), we divided the spraints contents into eight groups: mammals, birds, reptiles, amphibians, fishes, crayfish, insects and molluscs. For their identification we referred to some collections stored at the Department of Biology, University of Naples. In particular, mammals, birds, reptiles and amphibians were identified from their bones and/or teeth (in the case of reptiles, also from remains of exuviae); fishes were identified from their bones and scales; insects and other arthropods from their exoskeleton and/or remains of wings, legs and cuticles.

RESULTS AND DISCUSSION

On April 6th 2016, between 9.00 a.m. and 9:30 a.m., we sighted and recorded photos of an otter individual while eating, then while marking its terri-

Figure 1. Top right: map showing location of the Foce Sele-Tanagro Nature Reserve, Italy (empty black square); on the left: higher magnification of the black square showed in the map: black empty ellipse shows the area study. Figure 2. Calore river, study area.

tory out of the water and lastly while going into its supposed den (Figs. 3–5). Further sightings of single individuals were documented on May 20th, 2017 in the same spot, and on June 5th, 2018 south of the confluence of Sele and Calore rivers, in the morning. These sightings are interesting considering that otters are predominantly nocturnal.

Throughout the research period, many footprints of single individual, prey remains and 10 spraints were also found. The prey remains have been identified as freshwater crab *Potamon fluviatile* (Herbst, 1785), white-clawed crayfish *Austropotamobius pallipes* (Lereboullet, 1858), regarded as species complex, pond shrimp *Palaemonetes antennarius*

Figures 3-5. Otter photographed with Nikon D7000 + Tamron SP 70-300 mm F4-5.6 Di VC USD along the Calore river on April 6th, 2016 (photos by F. Bolinesi).

Class, Ordo	Species	HD Annex
Cephalaspidomorphi, Petromyzontiformes	*Petromyzon marinus*	II
Actinopterygii, Cypriniformes	*Alburnus albidus*	II
	Barbus plebejus	II, V
	Sarmarutilus rubilio	II
Amphibia, Anura	*Hyla intermedia*	IV
Reptilia, Squamata	*Lacerta bilineata*	IV
	Podarcis siculus	IV
	Elaphe quatuorlineata	II-IV
	Hierophis carbonarius	IV
	Natrix tessellata	IV

Table 1. Ichthyofauna and herpetofauna species listed in the Annexes to the Habitat Directive (Council Directive 92/43/EEC) observed in the study area.

Figure 6. Remains of *Natrix* sp. exuviae identified in the sp 2/2018 within the study area (photo by F.M. Guarino).

(H. Milne Edwards, 1837), and indeterminable fish species. We analyzed two spraints collected on April 9th, 2018 (sp 1/2018) and June 13th, 2018 (sp 2/2018), respectively. In the Sp 1/2018 we identified remains of: arachnids (a taxonomically unidentified individual); insects belonging to different families of the order Coleoptera: Familia Dytiscidae and Gyrinidae, water beetles, and Familia Carabidae; fishes: *Sarmarutilus rubilio* (Bonaparte, 1837) (Familia Cyprinidae); amphibians: only frogs belonging to Familia Ranidae, genus *Pelophylax* Fitzinger, 1843. In the Sp 2/2018 we identified remains of: insects (wings of unidentified taxa); fishes (unidentified taxa); reptiles, specifically water snake *Natrix* sp., likely *N. tessellata* (Laurenti, 1768), mainly based on remains of exuviae with dorsal scales keeled (Fig. 6); vegetable fragments. In none of the two spraints we identify remains of mammals, birds, crayfish and molluscs. On the whole, our analysis on spraints and prey remains are in agreement with previous studies (Gorgadze, 2013) by showing that otters consume a wide range of prey, even if most of their diet consists of fish. It is also well known that otter's diet varies according to habitats and seasons (MacDonald & Mason, 1982; Brzezinski et al., 1993; Gorgadze, 2013).

The Eurasian otter is categorized as "Near Threatened" by the IUCN Red List of Threatened Species but "Endangered" both by Red List of Italian Vertebrates (Rondinini et al., 2013) and Red list of terrestrial and freshwater vertebrates of Campania (Fraissinet et al., 2013). The critical status of the otter population in Campania has been mainly attributed to the alteration and fragmentation of the flowing-water habitats due to recent recrudescence in the exploitation of the territory (Fraissinet et al., 2013). However, our repeated sightings of otters along the Calore river network enlighten that this river might play an important role for the conservation and expansion of this species at regional level.

It is noteworthy that the study area is characterized not only by a river network suitable for the otter but also by widespread good environmental

quality where rich zoocenoses live, including numerous ichthyofauna and herpetofauna species listed in the Annexes to the Habitat Directive (Council Directive 92/43/EEC) (Tab.1) (Guarino & Maio, 2013). Other aquatic taxa of considerable interest for conservation biology found by the authors in the study area are the crayfish, *Austropotamobius pallipes* (Lereboullet, 1858), and the freshwater bivalve *Anodonta cygnea* (Linnaeus, 1758). The former species has been observed along the river since September 2002, besides the otter spraints, but so far it has never been reported in the Calore river (De Vico et al., 2011). *Anodonta cygnea* is a native species whose local population is potentially threatened due to *Sinanodonta woodiana* (I. Lea, 1834), an invasive alien species recently found at the mouth of the Sele river, probably introduced from Asia and Eastern Europe by placing various species of Cyprinidae for fishing purposes (Carella et al., 2013).

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Diatoms diversity and dynamics in a southern Mediterranean lagoon (Mellah, Algeria)

Mohamed Anis Draredja[1,*], Choukri Barour[1], Hocine Frihi[2], Chahinez Boualleg[1] & Mohamed Laabir[3]

[1]Laboratory of Aquatic and Terrestrial Ecosystems, Faculty of Natural and Life Sciences, M.C. Messaadia University, 41000 Souk Ahras, Algeria
[2]Marine Bioresources Laboratory, Faculty of Sciences. Badji Mokhtar University, 23000 Annaba, Algeria
[3]Center for Marine Biodiversity, Exploitation and Conservation (MARBEC), IRD, Ifremer, CNRS, University of Montpellier, Place E. Bataillon, CC93, 34095 Montpellier cedex 5, France
[*]Corresponding author, e-mail: draredjanis@gmail.com

ABSTRACT

The composition and distribution of diatoms were studied using a biweekly sampling performed in three representative stations in the Mellah Lagoon (South Western Mediterranean, Algeria), during 2016. In total, 160 diatoms species - belonging to centric species (52 species) and pennate species (108 species) - were inventoried. The relative abundance of the pennate forms (67.50%) is clearly higher compared to the centric forms (32.50%). The blooms of diatoms are represented by 3 species: *Chaetoceros constrictus* Gran, 1897 with up to 15000 cells.L^{-1} (end of May), *Chaetoceros* sp. with up to 178320 cells.L^{-1} (early October), and *Nitzschia longissima* (Brébisson) Ralfs, 1861 with up to 200640 cells.L^{-1} (early September). Proliferations of three potentially toxic species: *Pseudo-nitzschia group delicatissima* (Cleve) Heiden, 1928 (2500 cells.L^{-1}), *Pseudo-nitzschia* group *seriata* (Cleve) H. Peragallo, 1899 (700 cells.L^{-1}) and *Thalassionema nitzschoides* (Grunow) Mereschkowsky, 1902 (210 cells.L^{-1}), requires regular monitoring of this ecosystem where the exploitation of the shells is practiced. The diatom populations seem to be structured showing diversity (H') and equitability (J') indices reaching 4.56 bits.cell and 0.98 respectively, with the exception of spring-summer and summer-autumn transition periods.

KEY WORDS

Algeria; diatoms; diversity; Mellah lagoon; harmful species.

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INTRODUCTION

Coastal lagoons and adjacent wetlands play an important role in regulating environmental relations. Due to their multiple resources and proximity to the sea, they represent strategic locations for development and prosperity of human activities and therefore are subject to increasing anthropisation. These transitional ecosystems, between land and sea, are important ecosystems characterized by high biological productivity and biodiversity (Knoppers, 1994). However, the lagoons are very sensitive environments, fragile and extremely vulnerable, in relation to the organization of their living and non-living components which depends on the interaction between the natural components of the marine and continental areas (Dufour et al., 1994). Due to the wide variability of their physical, chemical and biological parameters, coastal lagoons are generally unstable environments. The

short- or long-term variations that occur in these ecosystems are important compared to saline marine environments. Consequently, the spatial and temporal variability of the quality of their waters depends on the importance of river inputs, tidal flows and evaporation.

Diatoms are microscopic single-cell plants that live in fresh, brackish and marine waters, from the poles to the tropics (Trainer et al., 2008). Diatoms belonging to the class of Diatomophyceae (Bacillariophycea) are an extremely diverse group. Mann (1999) reports that this class is highly diversified with species number estimated between 0.1 and 1 million. Their high photosynthesis activity and their tendency to dominate phytoplankton communities have led to their major involvement in primary production. It has been estimated that diatoms contribute to 40-45% of ocean primary productivity, accounting for 20% of global carbon sequestration and oxygen production (Yool & Tyrrell, 2003). They are the major phytoplankton in aquatic ecosystems and account for 20-25% of the oxygen release and carbon fixation in the world (Kale & Karthick, 2015). Diatoms are microalgae considered as the most sensitive to environmental conditions such as the organic pollution and the eutrophication (Licursia & Gómeza, 2013) and water density (Drira et al., 2009). Some diatom species are directly or indirectly responsible for health problems (Lefebvre & Robertson, 2010). Indeed some species especially the genus *Pseudo-nitzschia* H. Peragallo in H. Peragallo et M. Peragallo, 1900, are toxic and produce powerful neurotoxins (domoic acid) that can cause illness and even death in the elderly community (Trainer et al., 2008).

Diatomophyceae have been studied in the Mediterranean basin (Caroppo et al., 2005; Sahraoui et al., 2009; Solak et al., 2018). However, despite their ecological and biological importance in the marine ecosystems, to our knowledge no study has been devoted to it in the Mellah lagoon. The aim of this study is to determine the species composition and distribution of diatoms in the well preserved Mellah lagoon, South Mediterranean, Algeria (Fig. 1).

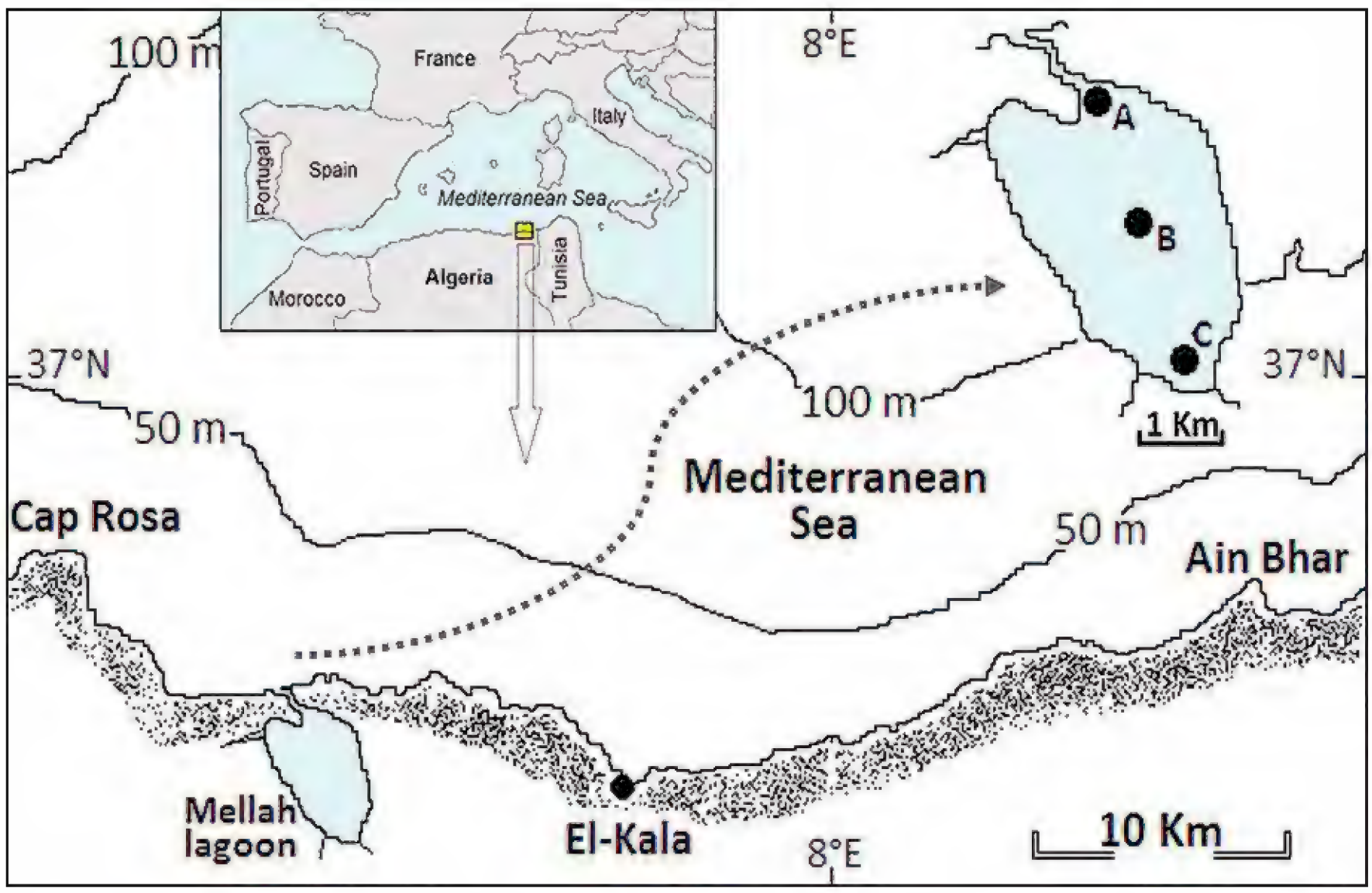

Figure 1. Geographical position of Mellah Lagoon
and location of sampling stations (South Mediterranean, Algeria).

MATERIAL AND METHODS

Study area and location of stations

The Mellah lagoon is located in the northeast of Algeria (36°54'N-8°20'E), within the El-Kala National Park created in 1983, a protected natural reserve and classified as biosphere reserve in 1990. The Mellah lagoon has a surface of 865 ha (depth < 5 m) and communicates with the sea by a channel (Fig. 1), which has undertaken substantial widening and deepening in 1988 (FAO, 1987) and is periodically dredged due to its recurrent filling with silt. The drainage system of the Mellah lagoon is characterized by three main intermittent streams located in southern sector of the lagoon, whose contribution to the overall nutrient loading is limited to the winter period. The Mellah lagoon is subject to a southern Mediterranean climate characterized by a dry and hot summer and a wet and cold winter.

During this study, three stations (St.A, St.B and St.C) were selected (Fig. 1): St.A (depth 2.50 m), located in the north of the lagoon no far from the inflow of marine waters; St.B (depth 4.80 m), situated in the center of the lagoon is the deepest zone and therefore under bathymetric influence; St.C (depth 1.50 m), fixed in the south of the lagoon near the inflow of the two rivers (south and southwest of the lagoon), subject to freshwater influences.

Physicochemical measurements, sampling and treatment of phytoplankton

Sampling of phytoplankton and measurements of some physicochemical parameters were carried out in three stations every 15 days during the year 2016. Physicochemical measurements were carried out in situ using a multiparameter HANNA HI9828. While the nutrients (NH4, NO2, NO3 and PO4) were assessed by spectrophotometry.

Phytoplankton sampling was conducted, where a volume of 50 liters of water was filtered using a standard plankton net (20 µm mesh size). Once collected, samples were fixed immediately with neutral formalin (concentration 4%). Identification of diatom species was performed according to Hendey (1964), Sournia (1986), Ricard (1987), Round et al. (1990), Chretiennot-Dinet et al. (1993), Tomas (1996) and Hasle et al. (1996). In the present work a detailed study on the identification and counting has been reserved only to the class of Diatomophyceae. The number of cells was estimated using Utermöhl's method (Utermöhl, 1958). Both identification and quantification of cell abundance (cells.L^{-1}) were made by an inverted light microscope (Leica DM750).

Ecological indices and statistical analysis

The spatiotemporal variation of the species rich-

Variables	St.A	St.B	St.C	Winter	Spring	Summer	Autumn
T	20.11±5.48a	20.37±5.61a	20.44±5.53a	13.64±1.31a	22.06±2.36b	26.86±1.50c	18.68±4.06b
Sal.	30.24±3.74a	30.13±3.65a	30.28±3.92a	25.56±1.30a	28.30±0.84a	33.55±1.91b	33.46±1.33b
DO	7.30±0.79a	7.30±0.81a	7.00±0.86a	7.54±0.66a	7.33±0.90a	6.80±0.72a	7.13±0.87a
pH	8.13±0.20a	8.10±0.22a	8.08±0.16a	8.07±0.13a	8.09±0.26a	8.08±0.15a	8.17±0.20a
SM	16.80±7.93a	16.16±7.89a	16.14±9.56a	27.47±5.00a	14.16±5.90	10.44±5.53b	13.38±4.54b
NH4	1.82±1.62a	1.74±1.55a	1.94±1.68a	2.54±1.98a	2.35±0.80a	1.59±1.33a,b	0.84±1.54b
NO2	0.32±0.26a	0.37±0.33a	0.37±0.29a	0.32±0.11a	0.61±0.46a	0.16±0.06b	0.33±0.14a
NO3	1.30±1.47a	1.04±1.68a,b	0.59±0.72b	0.84±0.36a	1.66±2.34a	0.73±0.90a	0.68±0.84a
DIN*	3.44±2.16a	3.15±2.61a	2.89±2.00a	3.70±2.17ab	4.62±2.66a	2.48±1.42b,c	1.85±1.58c
PO4	0.60±0.55a	0.54±0.49a	0.48±0.42a	0.57±0.52a	0.68±0.58a	0.44±0.29a	0.47±0.50a
Chl. *a*	2.21±1.86a	2.66±1.65a	2.20±1.85a	1.17±0.67a	2.85±1.87b	3.35±1.59b	2.07±1.94a,b

Table 1. Spatiotemporal variations (mean±se, n=72) in temperature (T, °C), salinity (Sal., p.s.u.), dissolved oxygen (DO, mg.L^{-1}), pH, suspended matter (SM, mg.L^{-1}), ammonium (NH4, µmoles.L^{-1}), nitrites (NO2, µmoles.L^{-1}), nitrates (NO3, µmoles.L^{-1}), dissolved inorganic nitrogen (DIN, µmoles.L^{-1}), phosphates (PO4, µmoles.L^{-1}) and chlorophyll a (Chl.*a*, µg.L^{-1}) in the Mellah lagoon waters. Different small letters indicate a significant difference between levels in each factor ($p<0.05$), using the Dunn's test. (*): DIN = NH4+ NO2 + NO3 (µmoles.L^{-1}).

ness (S) of diatoms group was calculated. The diversity index (H') used is that of Shannon & Weaver (1949). The regularity index (J') was calculated using the method of Piélou (1966). Furthermore, a principal component analysis (PCA) was performed using the Factoextra (Kassambara & Mundt, 2017) package on standardized data, whose objective is to characterize, by a multivariate approach, the structuring of spatiotemporal variations at the lagoon of Mellah. Statistical analyses were performed using R, version 3.4.2 (R Core Team 2017; Ihaka & Gentleman 1996) for Windows, by using Dunn's test package (Dinno, 2017); median differences among seasons were tested by Kruskal-Wallis test (rank-based nonparametric test) followed by post-hoc pairwise comparisons using Dunn's test with Holm's p-value adjustment. Results are given as means ± standard error. All the statistical analyses were performed at the statistical significance of $p<0.05$.

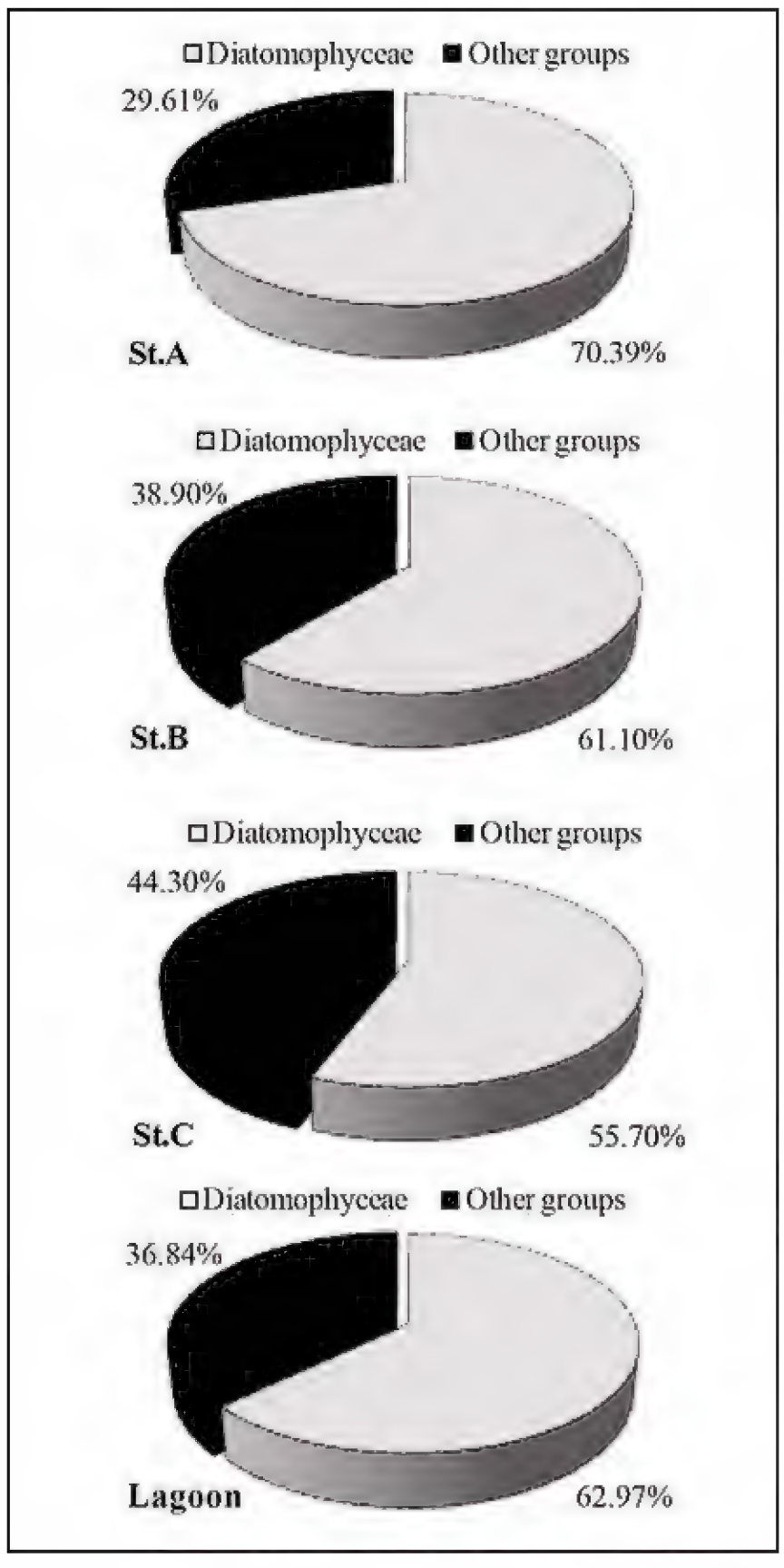

Figure 2. Relative abundances (%) of diatoms in the phytoplankton of Mellah lagoon, Algeria (2016).

RESULTS

Hydrological and environmental conditions

The spatiotemporal variations of physicochemical parameters are represented in Table 1. The application of the Kruskal-Wallis test for the comparison of physicochemical parameters in water showed that for nearly all parameters (T, Sal., DO, pH, SM, NH4, NO2, DIN, PO4, Chl*a*) no significant differences among the stations were recorded, with the exception of NO3 showing a minimum of 0.59±0.72 µmoles.L^{-1} at site C, and a maximum of 1.30±1.47 µmoles.L^{-1} at site A.

The monitoring of seasonal variations of physicochemical factors in the Mellah lagoon indicates that there are significant differences for all parameters except DO, pH, NO3, PO4 (Table 1). This is why the temperature values oscillate between 13.64±1.31°C in winter and 26.86±1.50°C in summer. Salinity showed a variation between 25.56±1.30 and 33.55±1.91 p.s.u. in winter and summer, respectively. Results about the suspended matter showed that the mean values ranged from 10.44±5.53 mg.L^{-1} in summer to 27.47±5.00 mg.L^{-1} in winter. We found that nutrient salt concentrations vary between 0.84±1.54 µmoles.L^{-1} in autumn and 2.54±1.98 µmoles.L^{-1} in winter for NH4; between 0.16±0.66 µmoles.L^{-1} in summer and 0.61±0.46 µmoles.L^{-1} in spring for NO2; between 1.85±1.58 µmoles.L^{-1} in autumn and 4.62±2.66 µmoles.L^{-1} in spring for DIN. The winter period was characterized by the lowest Chlorophyll a means with 1.17±0.67 µg.L^{-1} in winter, while the highest mean values were in the summer period with 3.35±1.59 µg.L^{-1}.

Composition of diatom communities

Diatom composition of Mellah lagoon was char-

acterized by a mixture of marine, brackish-water and freshwater taxa. Diatoms formed the most dominant group and contributed greatly to the total phytoplankton at almost all the stations (55.70-70.39%) (Fig. 2). Over 62.97% of total phytoplankton taxa were represented throughout the lagoon. In all stations we identified 160 species belonging to the Diatomophyceae (Table 2). The diatoms were represented by 52 centric and 108 pennate species. Among the Centrales, several families such as Catenulaceae (15 species), Thalassiosiraceae (8 species) and Triceratiaceae (5 species) were recorded, while for the Pennates, three were the most rich in species: Bacillariaceae (22 species), Naviculaceae (16 species) and Pleurosigmataceae (14 species) (Table 2). However, in the three stations the centric forms are dominant (50.01-92.15%), compared to the pennate forms.

Population density and distribution

The spatiotemporal variation in the density of diatoms is reported in figure 3. The maximum density of this phytoplankton group varies be-

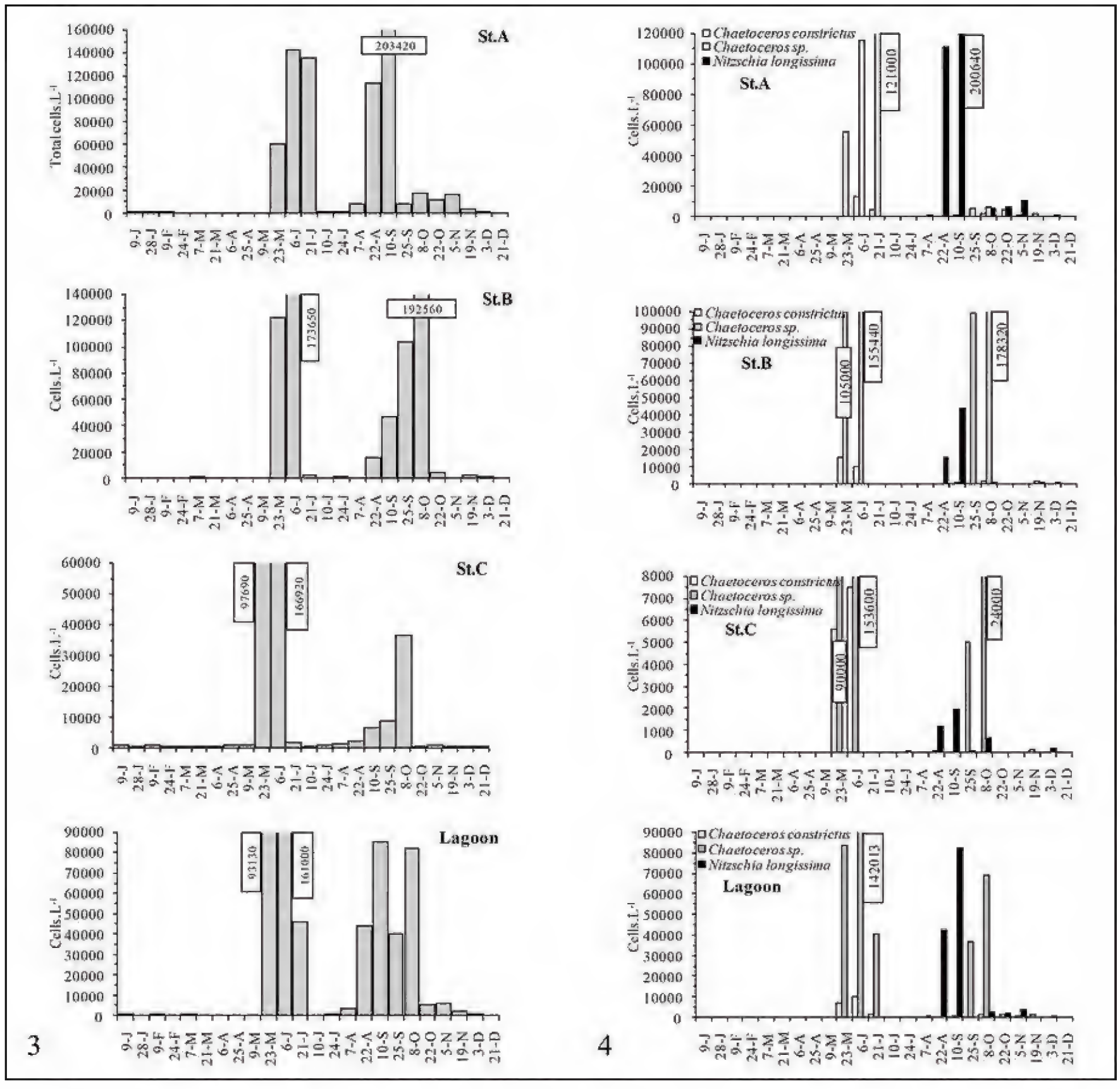

Figure 3. Spatiotemporal variations of density (cells.L^{-1}) of diatoms collected in the Mellah lagoon, Algeria (2016). Figure 4. Spatiotemporal variations of abundance (cells.L^{-1}) of diatom species with efflorescence in the Mellah lagoon, Algeria (2016).

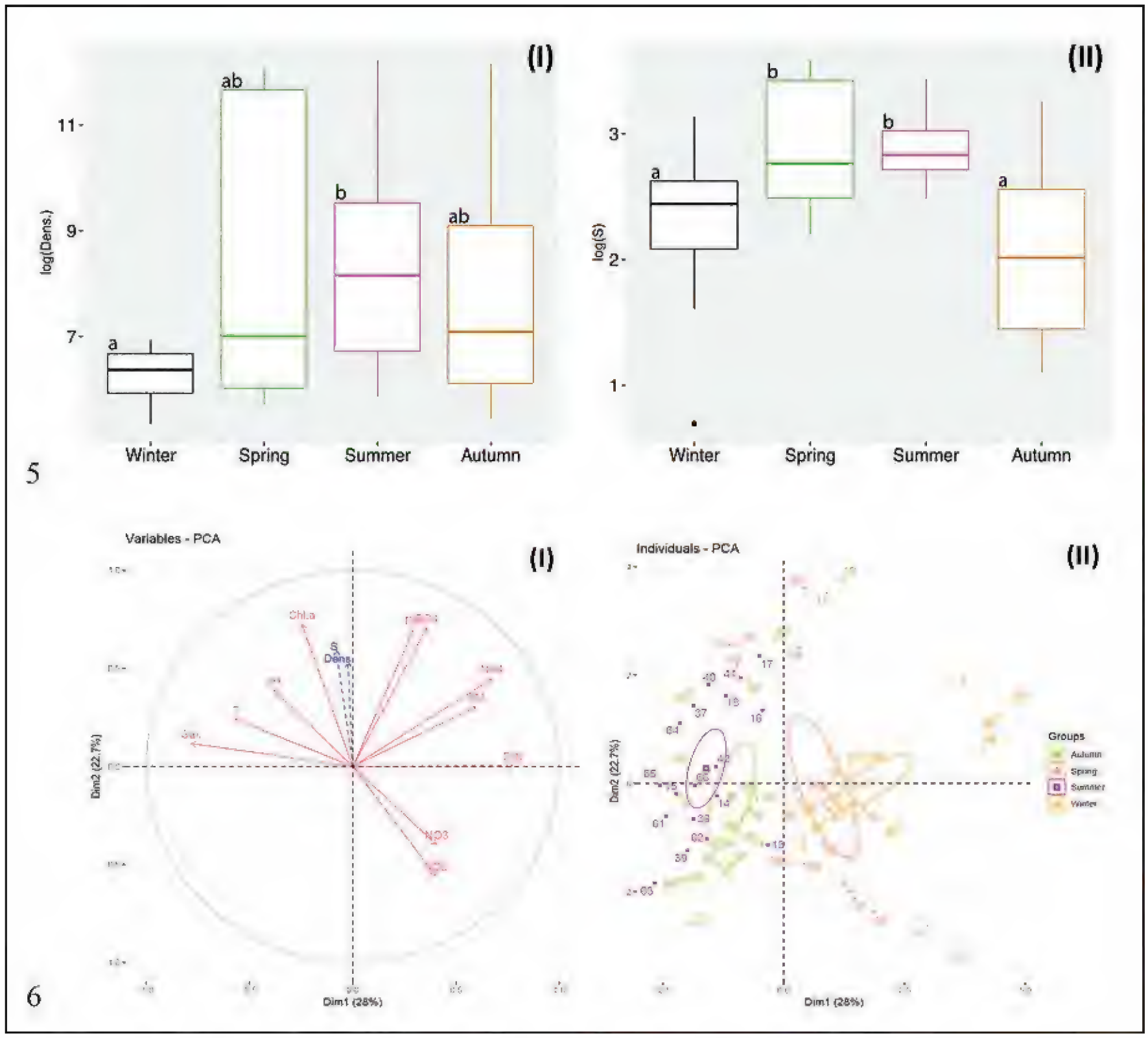

Figure 5. Seasonal variations in density (Dens.) (I) and species richness (S) (II) of diatoms in the Mellah lagoon (n=72). Boxplots labeled with the same letter are not significantly different at $p<0.05$. Central box limits show the interquartile range (IQR) with the first (lower box bound) and third (upper box bound) quartiles. Outliers (values outside IQR limits ± 1.58 times IQR) are indicated by small circles.

Figure 6. Principal Component Analysis (PCA) based on correlation between diatoms density and species richness and the environmental parameters (I); PCA analysis score plot (Dim1 vs Dim2) based on the monitored seasons in the Mellah lagoon (II). (Factorial plane: Dim1=28%, Dim2=22.70%).

tween 97690 cells.L^{-1} (St.C, end of May) and 203420 cells.L^{-1} (St.A, early September). According to the period and the station, among the 160 species only a few (about three) are clearly dominant. The majority of the species are therefore very poorly represented. The species that are responsible for high abundances are shown in figure 4. Only 3 species causing blooms were detected: *Chaetoceros* sp. with up to 178320 cells.L^{-1} (St.B, early October), *Chaetoceros constrictus* with up to 15000 cells.L^{-1} (St.B, end of May) and *Nitsctzschia longissima* with up to 200640 cells.L^{-1} (St.A, early September). The list of the microalgae contains three species classified as potentially toxic: *Pseudonitzschia delicatissima* (2520 cells.L^{-1}, St.A, early November), *P. seriata* (700 cells.L^{-1}, St.A, early November) and *Thalassionema nitzschoides* (210 cells.L^{-1}, St.B, end of September). The application of the Kruskal-Wallis test for density and specific richness showed that there is a significant difference

among seasons and no significant differences among stations. The inter seasonal variations of diatoms density and specific richness in the lagoon are reported in figure 5, I. Regarding density, the extreme mean values are 590.56±266.45 cells.L^{-1} in winter and 50295.56±6817.43 cells.L^{-1} in spring. However, seasonal variation of diatoms showed different dispersions. Concerning the qualitative composition, the differences in mean inter seasonal values are also important, because they varied between 9.89±7.12 in autumn and 20.28±9.78 in spring (Fig. 5, II).

The use of Principal Component Analysis (PCA) as a preliminary and exploratory descriptive approach made it possible to visualize the structuring of the seasonal and spatial variation in the three stations according to 11 physicochemical variables: water temperature (T), pH, salinity (Sal.), dissolved oxygen (DO), nitrates (NO3), nitrites (NO2), Ammonium (NH4), dissolved inorganic nitrogen (DIN) phosphates (PO4), suspended matter (SM), chlorophyll a (chl. a), and two biological variables: specific richness (S) and density (Dens.) (Fig. 6).

The PCA clearly shows that the first two factorial axes yielded nearly 50.70% of the information (Fig. 6, I). Axis 1, explaining 28% of the total variation, is positively correlated with the variables DIN (r=0.77), NH4 (r=0.67), SM (r=0.59), which strongly contribute to the construction of this axis (cos^2=0.6, cos^2=0.45, cos^2=0.35, respectively); and negatively with the variables Sal. (r=-0.78), T (r=-0.57) and pH (r=-0.38), which also contribute significantly to its construction (cos^2=0.61, cos^2=0.32 and cos^2=0.15, respectively). In addition, axis 2, explaining 22.7% of the total variation, is built mainly by the strong positive correlations of the variables Chl.*a* (r=0.73), PO4 (r=0.71), DO (r=0.70), S (r=0.59) and Dens. (r=0.53) and the negative correlation of variables NO2 (r=-0.56) and NO3 (r=-0.40) which contribute considerably to its construction (cos^2=0.53, cos^2=0.50, cos^2=0.49, cos^2=0.35, cos^2=0.28, cos^2=0.31 and cos^2=0.16 respectively). Regarding seasonal variation (Fig. 6, II), we noted that summer is characterized by high values of salinity and temperature. In autumn it's pH, Chl.*a*, density and the specific richness of diatoms which dominate. Spring is characterized by higher concentrations of DO, PO4, NO2, NO3. Finally, NH4, SM, and DIN dominate during winter season.

Species diversity and ecological indices

The number of species (S) and range of diversity indices in the study area are shown in figure 7. In particular, the maximum number of species (36) was observed in the north of the Mellah at St.A (early June); St.C, in the south of the Mellah, was the least rich (32 species, end of June) and St.B, in the center of the lagoon, was characterized by a specific richness of 34 species. Shannon index of diversity (H') values generally increased in parallel to the number of species (S) and evenness index (J') throughout the study period. This trend was observed only for stable ecosystems. This is not the case of the Mellah lagoon, which is characterized by the fact that it is punctually pound during ad-

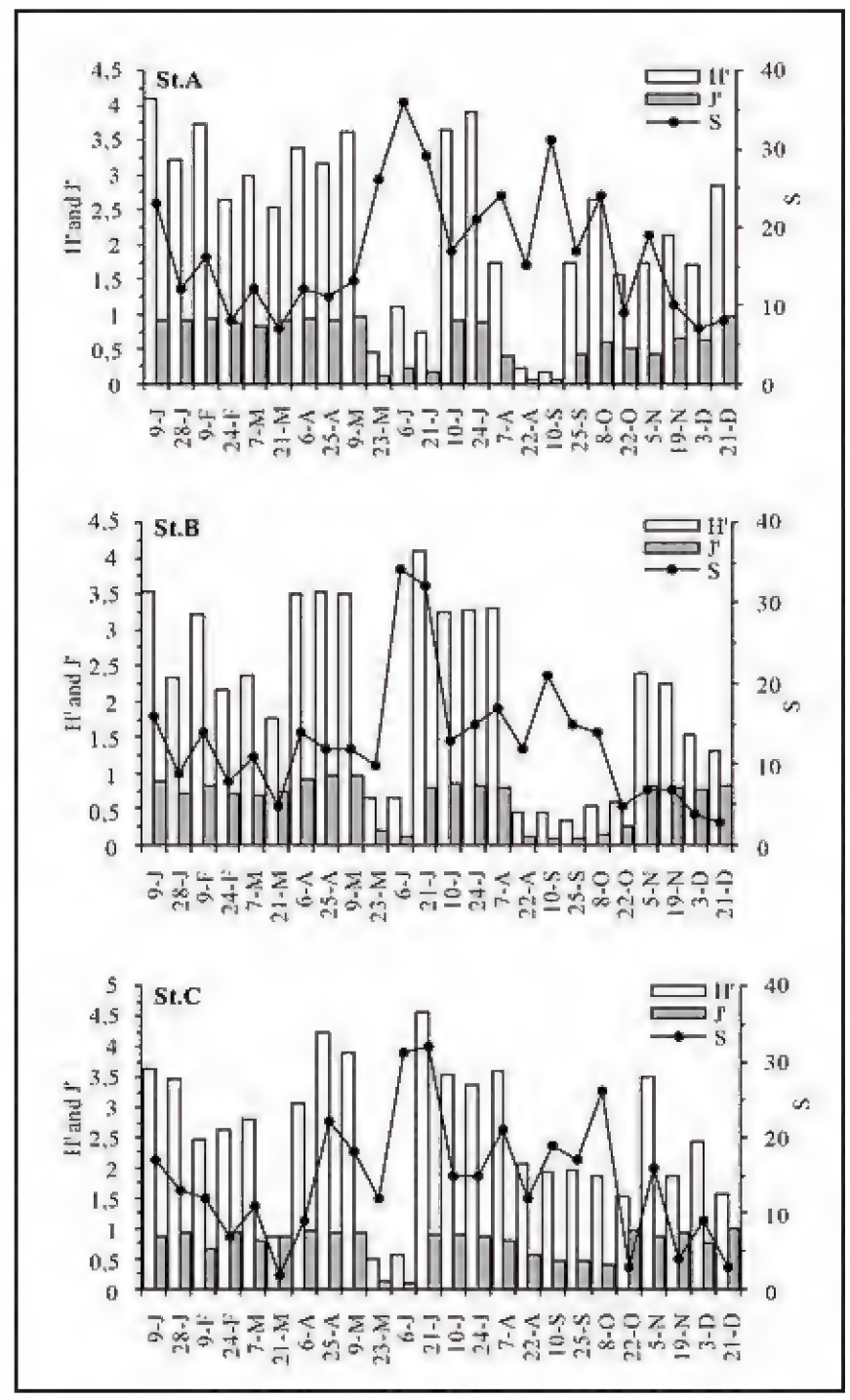

Figure 7. Spatio-temporal variations of species number (S), Shannon diversity index (H') and Piélou evenness index (J') of diatoms in the Mellah lagoon, Algeria (2016).

CENTRIC

Catenulaceae Mereschkowsky, 1902
Amphora arenaria Donkin, 1858 (M)
A. coffeaeformis (C. Agardh) Kützing, 1844 (M)
A. decussata Grunow, 1877 (M)
A. dubia Gregory, 1857 (M)
A. gigantea Grunow (M)
A. laevis Gregory, 1857 (M)
A. lineolata Ehrenberg, 1838 (M)
A. marina W. Smith, 1857 (M)
A. ocellata Donkin, 1861 (M)
A. ovalis (Kützing) Kützing, 1844 (M)
A. proboscidea Gregory, 1857 (M)
A. proteus Gregory, 1857 (M)
A. ostrearia Brébisson, 1849 (M)
A. sulcata Brébisson, 1854 (M)
A. terroris Ehrenberg, 1853 (M)

Chaetocerotaceae Ralfs, 1851
Chaetoceros constrictus Gran, 1897 (M)
C. pseudobrevis Pavillard, 1911 (M)
C. radicans F. Schütt, 1895 (M)
Chaetoceros sp.

Coscinodiscaceae Kützing, 1844
Coscinodiscus centralis Ehrenberg, 1844 (M)
C. obscurus Schmidt, 1858 (M)
C. subtilis Ehrenberg, 1841 (M)
Coscinodiscus sp.

Hyalodiscaceae Crawford, 1990
Hyalodiscus scoticus (Kützing) Grunow 1879 (M)
Podosira stelligera (Bailey) A. Mann, 1907 (M)

Hemidiscaceae Hendey, 1937 emend Simonsen, 1975
Pseudoguinardia recta Von Stosch, 1986 (F)

Lauderiaceae (Schütt) Lemmermann, 1899, sensu emend.
Lauderia borealis Gran, 1900 (M)

Leptocylindraceae Lebour, 1930
Leptocylindrus danicus Cleve, 1889 (M)

LithosdemiaceaeRound, 1990
Lithodesmium undulatum Ehrenberg, 1839 (M)

Melosiraceae Kützing, 1844, sensu emend.
Melosira moniliformis (O.F. Müller) C. Agardh, 1824 (M)
M. nummuloides C. Agardh, 1824 (M)
Melosira sp.

Paraliaceae Crawford, 1988
Paralia sulcata (Ehrenberg) Cleve, 1873 (L)

Rhizosoleniaceae De Toni, 1890
Guinardia flaccida (Castracane) H. Peragallo, 1892 (M)
Rhizosolenia delicatula Cleve, 1900 (M)
R. imbricata Brightwell, 1858 (M)
R. stolterfothii H. Peragallo, 1888 (M)

Skeletonemaceae Lebour, 1930, sensu emend.
Skeletonema costatum (Greville) Cleve, 1873 (M)

Syracosphaeraceae Lemmermann, 1908
Syracosphaera pulchra Lohmann, 1902 (M)

Thalassiosiraceae Lebour, 1930
Planktoniella sol (C.G. Wallich) Schütt, 1892 (M)
Thalassiosira fallax Meunier, 1910 (M, L, F)
T. lineata Jousé, 1968 (M)
T. nordenskioeldii Cleve, 1873 (M)
T. visurgis Hustedt, 1957 (L, F)

Triceratiaceae (Schütt) Lemmermann, 1899
Auliscus caelatus Bailey, 1854 (M)
Cerataulus radiatus R. Rross, 1986 (M)
Odontella cf. *rostrata* (Hustedt) Simonsen, 1987 (M, L)
Triceratium antediluvianum (Ehrenberg) Grunow, 1868
T. favus Ehrenberg, 1839 (M)
T. pelagicum(J.L.B. Schröder) Sournia, 1968 (M)
*T. shadboltianum*R.K. Greville, 1862 (M)
Triceratium sp.

PENNATE

Achnanthaceae Kützing, 1844
Achnanthes brevipes Agardh (L)

Amphipleuraceae Grunow, 1862
Amphiprora hyperborea (Grunow, 1880) (M)
Amphiprora sulcata (O'Meara, 1871) (M)
Amphiprora sp.

Auriculaceae Hendy, 1964
Auricula amphitritis Castracane, 1873 (M)

Bacillariaceae Ehrenberg, 1831
Bacillaria paradoxa J.F.Gmelin in Linnaeus, 1791 (M)
Hantzschia virgata (Roper) Grunow in Cleve & Grunow 1880 (M)
Nitzschia acula (Kützing) Hantzsch in Rabenhorst, 1861 (F)
N. acuminata (W. Smith) Grunow, 1880 (M)
N. angularis Smith, 1853 (M)
N. closterium Eulenstein, 1868 (F)
N. constricta (Gregory) Grunow, 1880 (F)
N. cylindrus (Grunow ex Cleve) Hasle, 1972 (M)
N. dubia W. Smith, 1853 (F)
N. fasciculata (Grunow) Grunow in Van Heurck, 1881 (F)
N. incurva Grunow *in* O. Schneider, 1878 (F)
N. linearis W.Smith, 1853 (M, F)
N. longissima (Brébisson) Ralfs, 1861 (F)
N. obtusa W. Smith, 1853 (M, F)
N. polaris Grunow ex Cleve, 1883 (M)
N. punctata (W. Smith) Grunow, 1878 (M)
N. sigma (Kützing) W. Smith, 1853 (F)
N. spathulata W. Smith, 1853 (M)
N. ventricosa Kitton, 1873 (M)
Nitzschia sp.
Pseudo-nitzschia delicatissima (Cleve) Heiden, 1928 (M) (T)
P. seriata (Cleve) H.Peragallo, 1899 (M) (T)

Climacospheniaceae
Climacosphenia monoligera Ehrenberg, 1843 (M)

Cocconeidaceae Kützing, 1844
Cocconeis molesta Kützing (M)
C. placentula Ehrenberg, 1838 (M)
C. pseudomarginata Gregory, 1857 (M)
C. stauroneiformis (W. Smith) H. Okuno, 1957 (M)
Cocconeis sp.

Cymatosiraceae Hasle, von Stosch & Syvertsen, 1983
Campylosira cymbelliformis (A. Schmidt) Grunow ex Van Heurck, 1885 (M)
Minutocellus scriptus Hasle, von Stosch & Syvertsen, 1983 (M)

Cymbellaceae (Greville, 1833)
Cymbella cymbiformis (Ehrenberg) Grunow in Van Heurck, 1880 (M)
Cymbella inaequalis Ross, 1852 (M)
Cymbella helvetica Schmidt in Schmidt et al., 1881 (F)

Diploneidaceae D.G. Mann, 1990
Diploneis bomboides(A.W.F. Schmidt) Cleve, 1894 (M)
D. bombus (Ehrenberg) Ehrenberg, 1853 (M)
D. crabro (Ehrenberg) Ehrenberg, 1854 (L)
D. didyma (Ehrenberg) Ehrenberg, 1839 (M)
D. incurvata (Gregory) Cleve, 1894 (M)
Diploneis sp.

Fragilariacées (Dumortier, 1823)
Fragilaria islandica Grunow ex Van Heurck, 1881 (M)
Synedra acus Kützing, 1844 (F)
S. cristallina (L, F)
S. fasciculata Ehrenberg, 1832 (F)
S. ulna (Kützing) Skabichevskii, 1959 (F)
Synedra sp.

Licmophoraceae Kützing, 1844
Licmophora abbreviata C. Agardh, 1831 (M)
L. ehrenbergii (Kützing) Grunow, 1867 (M)
L. flabellata (Greville) Agardh (M)
L. reichardtii Grunow, 1881 (M)
L. robusta H. Peragallo & M. Peragallo (M)
L. tenuis (Kützing) Grunow, 1867 (M)
Licmophora cf. *tincta* (C. Agardh) Grunow, 1868 (M)

Lyrellaceae D.G. Mann
Lyrella hennedyi (W. Smith) Stickle & D.G. Mann, 1990

Naviculaceae (Kützing, 1844)
Haslea ostrearia (Gaillon) Simonsen, 1974 (M)
H. wawrikae (Hustedt) Simonsen, 1974 (M)
Navicula cryptocephala Kützing, 1844 (M)
N. distans (W. Smith) Ralfs, 1861 (M, L)
N. flanatica Grunow, 1860 (L, F)
N. gregaria Donkin, 1861 (M, L, F)
N. pavillardi Hustedt, 1939 (L)
N. pennata A.W.F. Schmidt (F)
N. pupula Bristol, 1920 (F)
N. radiosa Kützing, 1844 (F)
N. ramosissima (C. Agardh) Cleve, 1895 (M)
N. retusa H. Lange-Bertalot & K. Bonik, 1976 (M, L)
N. salinarum Grunow, 1880 (L, F)
N. spicula (Hickie) Cleve, 1894 (M, F)
N. viridula Neupauer, 1867 (F)
Navicula sp.

Pinnulariaceae D.G. Mann, 1990
Oestrupia sp. (M)

Plagiotropidaceae D.G. Mann
Plagiotropis lepidoptera (Gregory) Kuntze, 1898 (L)
P. conserta (Lewis) Kuntze, 1898 (M)
P. vitrea (W. Smith) Grunow, 1880 (M)
Plagiotropis sp.

Pleurosigmataceae Mereschkowsky, 1903
Gyrosigma balticum (Ehrenberg) Rabenhorst, 1853 (M)
G. distortum (W. Smith) Griffith & Henfrey, 1856 (M, F)
G. littorale (W. Smith) Griffith & Henfrey, 1856 (M)
G. prolongatum (W. Smith) J.W.Griffith & Henfrey 1856 (M)
G. scalproides (Rabenhorst) Cleve, 1894 (L, F)
Pleurosigma angulatum (Queckett) W. Smith, 1852 (M)
P. delicatulum W. Smith, 1852 (M, L)
P. elongatum W. Smith, 1852 (M, L, F)
P. formosum W. Smith, 1852 (L)
P. giganteum Grunow, 1880
P. lanceolatum Donkin, 1858 (M)
P. obscurum W. Smith, 1852 (L)
P. stuxbergi Cleve & Grunow, 1880 (M)
Pleurosigma sp.

Rhabdonemataceae Round & R.M. Crawford
Rhabdonema adriaticum Kützing, 1844 (M)
R. arcuatum Kützing, 1844 (M)

Rhopalodiaceae (Karsten) Topachevs'kyj & Oksiyuk, 1960
Epithemia turgida (Ehrenberg) Kützing, 1844 (F)

Stauroneidaceae D.G.Mann, 1990
Stauroneis africana Amossé, 1934
S. spicula Hickie, 1874 (M)

Striatellaceae Kützing, 1844
Grammatophora oceanica Ehrenberg, 1840 (M)
Striatella unipunctata (Lyngbye) C. Agardh, 1832 (M)

Surirellaceae Kützing, 1844
Campylodiscus fastuosis Ehrenberg, 1845 (M)
Surirella fastuosa (Ehrenberg) Ehrenberg, 1843 (M)
*S. ovata*Ehrenberg, 1844 (1845) (F)
S. striatula Turpin, 1828 (M)

Tebellariaceae Kützing, 1844
Tabellaria fenestrata (Cleve) Skabichevskii, 1960 (M)

Thalassionemataceae Round, 1990
Thalassionema nitzschioides (Grunow) Mereschkowsky, 1902 (M) (T)
Thalassiothrix delicatula Cupp, 1943 (M)
T. longissima Cleve & Grunow, 1880 (M)

Table 2. Check list of diatoms species identified in Mellah lagoon, Algeria (2016).
F: freshwater, M: marine, L: lagoon, T: potentially toxic).
Classification depending on Website WoRMS: http://www.marinespecies.org/ and AlgaeBase: http://www.algaebase.org).

verse situations. The highest diversity (H'=4.56 bits/cell) was observed at St.C (end of June) and the lowest value (H'=0.15 bits/cell) was detected at St.A (early September), while Piélou evenness index varies between 0.03 (St.A, early September) and 0.98 (St.C, end of December) (see Fig. 7).

DISCUSSION AND CONCLUSIONS

Our results highlighted the hydrological peculiarities of this lagoon ecosystem. The thermal variations of Mellah lagoon waters (12.26-28.26°C) are comparable to the majority of southern Mediterranean lagoons (Béjaoui et al., 2010; El-Madani et al., 2011; Bellakhal Fertouna & Bellakhal, 2013; Dhib et al., 2016). However, the salinity extreme values (23.98-36.23 p.s.u.) are often lower compared with ecosystems of neighboring countries including Bizerte lagoon in Tunisia (Sahraoui et al., 2009; Béjaoui et al., 2010) and Nador lagoon in Morocco (El-Madani et al., 2011). Overall Mellah lagoon waters are well oxygenated unlike some Mediterranean lagoons which are characterized by periodic dystrophy crisis when the dissolved oxygen can reach critical values (Lenzi et al. 2003; Viaroli et al., 2006; Marinov et al., 2008; El Madani et al., 2011; Pachés et al., 2014).

Regarding the spatiotemporal distribution of nutrients, unlike the majority of Mediterranean lagoons which are often characterized by a significant enrichment in nutrient salts (Souchu et al., 2010; El Madani et al., 2011; Satta et al., 2014; Pachés et al., 2014; Zaaboub et al., 2014), the Mellah lagoon, due to its waters less rich in nutrients, ranks among the meso-oligotrophic lagoons (OECD, 1982). These particular physicochemical characteristics lead to a low chlorophyll a production not exceeding 5.84 $\mu g.L^{-1}$ with an annual average of 2.41 $\mu g.L^{-1}$. These values are often low compared to several lagoons in the Mediterranean (Badosa et al., 2008; Roselli et al., 2009; Cañedo-Argüelles et al., 2012; Bernardi Aubry et al., 2013; Pachés et al., 2014). This physicochemical and hydrological situation is the result of a double effect. First, the Mellah Lagoon is a body of water that is located within the El-Kala National Park; a protected nature reserve since 1983, so far from any source of pollution or anthropogenic action. Then, the narrowing of the communication channel with the sea, which has not been dredged since 1988, has further reduced water exchanges with the adjacent Mediterranean coast (Ounissi et al., 2002). In addition, in this region there is a low urbanization limited to a few houses of traditional construction.

The majority of species belong to diatoms, many of which have a benthic affinity. These forms of diatoms are still common in lagoon environments as highlighted by Mallissen & Lasserre (1979). It appears that the richness of diatoms is related not only to tidal regime turbulence (leading to benthic and tychopelagic forms in the water column), but also to their ability to directly draw nutrients from the water-sediment interface (Bonin, 1988). Investigating diatoms in the Mellah lagoon allowed us to identify 160 taxa, most of which belonging to the marine contingent. The typical lagoon species are very few (only 16). Although the low nutrient levels, the number of diatom species reached 160. Interestingly, this moderate diatom specific richness observed in Mellah lagoon exceeded those of some other Mediterranean ecosystems: Lake of Tunis (Benrejeb-Jenhani & Romdhane, 2002), two lagoons in the Sfax saltern (Ayadi et al., 2004), Nador lagoon (El Madani et al., 2011), Venice lagoon (Bernardi Aubry et al., 2013) and Cullera Estany lagoon (Pachés et al., 2014).

In the present study, the maximum number of taxa (53) is observed at station A, situated in the north of the Mellah lagoon in front of the channel communicating with the sea, therefore under marine influence. The minimum number of taxa (43) is found at Station C, confined in the extreme south of the lagoon and under continental influence. The difference in species richness between these two sites shows that several phytoplankton populations come from the adjacent coast by the channel that connects the lagoon to the sea. In the Mellah lagoon, diatoms are the dominant (qualitatively and quantitatively) group within microphytoplankton. This dominance characterizes not only the majority of Mediterranean lagoons (Benrejeb-Jenhani & Romdhane, 2002; Bernardi Aubry & Acri 2004; El Madani et al., 2011; Bernardi Aubry et al., 2013; Nassar & Gharib, 2014), but also the waters of the open Mediterranean coast (Percopo et al., 2011; Drira et al., 2014; Taş, 2014; Khairy & Gharib, 2017; Rekik et al., 2017). However, despite the meso-oligotrophy of the Mellah lagoon, we can observe that the number of diatom cells were rela-

tively important (up to 203420 cells.L^{-1}) in the north of the lagoon. This zone of the lagoon could form a site for accumulation of marine species (brought back by the channel during the flow phase) and, to a lesser extent, for the arrivals of freshwater tolerant species transported by the three rivers that discharge there. In the Mellah lagoon, the main blooming species is *Nitzschia longissama* with a maximum abundance of 200640 cells.L^{-1} recorded at Station A (north of the lagoon), in the end of summer. The end of the bloom could result from increasing oxygen demand and the decrease of nutrients.

The application of the Kruskal-Wallis test for the abundance showed that there is a significant difference among the seasons. The Principal Component Analysis (PCA) explains the positive role played by nutrients (mainly with PO4 and secondary with NH4) in the proliferation and diversification of diatoms. Indeed, the meso-oligotrophic character of the waters of the lagoon implies the role played by these nutrients as soon as they increase in the water column. Though high temperature and salinity during the summer season limit the proliferation of this group of phytoplankton, nevertheless, diatoms in the Mellah lagoon are characterized by optimal development and structuring during the spring-summer and summer-autumn transition phases, when thermal conditions are moderate.

Diatom populations of the Mellah lagoon showed a diversity that can reach 4.56 bits.cell.-1 and a regularity of 0.98, thus suggesting structured diatom populations for only a period of the year (winter and end of spring). However, the rest of the cycle is characterized by an unstable species composition. In this case, only the opportunistic species develop, well adapted to the unfavorable environmental factors (mostly temperature) (Mozetic et al., 1998; Bianchi et al., 2003). We noted that the maximum values of diversity (H') in the Mellah lagoon are higher than those recorded in other Mediterranean lagoons. Indeed, in the Venice lagoon (Italy) Bernardi Aubry & Acri (2004) reported a maximum value of H' that barely touches 3 bits.cell.-1, whereas in the Berre pond (France) this index was around 2 bits.cell.-1 (Beker, 1986).

Our results revealed the existence of three potentially toxic species belonging to the group of diatoms: *Pseudo-nitzschia delicatissima*, *P. seriata* and *Thalassionema nitzschoides*. These species have been reported to produce domoid acid responsible of ASP (Amnesic Shellfish Poisoning) syndrome. The most abundant potentially harmful species is *Pseudo-nitzschia delicatissima* (up to 2520 cells.L^{-1}). Cell densities of *P. seriata* and *T. nitzschoides* were usually low and often imperceptible in quantitative samples, their maximum abundances ranging between 210 and 700 cells.L^{-1}. The appearance of these three potentially toxic species occurs in late summer and autumn; this situation is an alarm for shellfish farmers in the lagoon which could be confronted to harmful blooms and intoxication of the mollusks in the near future. Sahraoui et al. (2009) reported the presence of toxic *Pseudo-nitzschia* species in Bizerte lagoon (Tunisia). In French coastal waters, *Pseudo-nitzschia* are known to bloom during the spring (Quiroga, 2006).

In conclusion, it appears: (1) Unlike the majority of Mediterranean lagoons, which are eutrophic, the Mellah lagoon is distinguished by its meso-oligotrophy, due to its remoteness from any source of pollution. (2) Despite the limitation of nutrients in this lagoon, it holds a diatom specific richness which exceeds that of many lagoons in the Mediterranean. (3) The optimal conditions for the development of diatoms in the lagoon correspond to the phases where the water temperature is moderate in parallel to the increase of the nutrients input (firstly with PO4 and secondary with NH4), that is during the seasonal transition periods spring-summer and summer-autumn. (4) The presence of some potentially toxic species, nowadays three in number, points out the need of the establishment of a regular monitoring of harmful species - as shellfish culture has been practiced for several years in this lagoon - to reduce (or even avoid) the risk of human intoxication.

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Inventory of scorpion fauna (Arachnida Scorpiones) in Tiaret region (Algeria)

Fatma Bousmaha[1*], Malika Adamou-Djerbaoui[2], Fatiha Labdelli[2], Mohamed Essalah Azzaoui[3], Fatima Beldjillali[2], Khadidja Raci[2], Khadidja Titaf[2] & Walid Dahmani[2]

[1]Hygienique and pathological animal Laboratory Veterinary school, IbnKhaldoun University, Tiaret, Algeria
[2]Faculty of Sciences of Nature and Life and Laboratory of Agro-Biotechnology and Nutrition in Semi-Arid Zone, Ibn Khaldoun University of Tiaret, Algeria
[3]Higher School of Agronomy Mostaganem, Algeria
[*]Corresponding author: fleurs_jasmin@yahoo.fr.

ABSTRACT The present work was carried out in the region of Tiaret to study the diversity of scorpions in western Algeria. In this locality, three stations were chosen: the first one is a rocky area, the second one is represented by a scrub and the third is an anthropized zone. The scorpions sampling was done, during the year 2017, randomly and it was carried out by searching the scorpions in their hiding places, where a total of 200 individuals were sampled. The specimens morphometry, based on the measurement of 8 parameters, made it possible to diagnose two families: Buthidae represented by two species *Buthus occitanus* (Amoreux, 1789) (88.5%) and *Buthacus arenicola* (Simon, 1885) (7%) and Scorpionidae represented by *Scorpio maurus* Linnaeus, 1758 (4.5%). Among the measures that make the difference between these species, we mention the width of the chela, which is of the order of 3.03 ± 0.67 for *Buthus occitanus* and 2.27 ± 0.49 mm for *Buthacus arenicola*, while *Scorpio maurus* has larger chela.

KEY WORDS Algeria; Buthidae; Inventory; Scorpionidae; Tiaret.

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INTRODUCTION

Scorpions form an order of about 600 species, all thermophiles, of which none exceeds, so northward as southward 50 degrees of latitude (Boué & Chanton, 1974). Scorpions occur in tropical and subtropical regions and also in more moderated regions of hemispheres like in the North and the South of America. In North America they unfold far in the northern regions and in Canada (approximately 52° N). In South America, scorpions occur in the south of Chile and in Argentina (approximately 50° S).

Scorpions show different models of adaptation to various types of environments, even inhabited by humans. Several works were made on the scorpions. Simon (1910) made a revision of the scorpions of Egypt that were the object for a works by Vachon (1952; 1974; 1975). El Hennawy (1992) wrote a catalog of the scorpions of Arab countries. Polis (1990) noted that the diversity of the scorpions is relevant in deserts and dry regions and other contributions were made by Lourenço et al. (2002, 2003), Lourenço & Leguin (2011), Touloun (2004), Touloun et al. (2001, 2014), Touloun & Boumezzough (2011), and Badry et al. (2017).

For this reason, our study is an attempt to determine the inventory of the Fauna scorpions in the region of Tiaret, West Algeria. The investigation is

done through the morphometry of these scorpions in three stations of the region of Tiaret.

MATERIAL AND METHODS

The present study uses a random sampling selection of scorpions. The scorpions collection were carried out in three stations. The first station is Mellakou, represented by a rocky naked ground and situated at a height between 943 and 1114 meters. The second station is Ledjdar, a scrubland situated at a height between 1114 and 1491 meters. The third station is Guertoufa, a mountainous and anthropized zone, situated at a height between 275 and 943 meters. The collection of the scorpions in the various stations was made by looking for the scorpions in their hiding places, under wooden branches, debris or stones.

Each scorpion was kept individually in a glass jar. The date of the collection, the site and number were mentioned on the jar. In the laboratory, several measures of morpho-metric were taken to the collected scorpions, like the total length, the length of the prosoma, mesosoma, metasoma, length of the vesicle with poison, length and width of the femur, the patella, the length of the mobile finger and others.

RESULTS AND DISCUSSION

A morphological examination of the collected scorpions was made by the keys of identification of Vachon (1952) and other similar works (Lourenço, 2006; Lourenço & Vachon, 2004).

The scorpions found in the three Algerian stations belong to two families and three species. Family of Buthidae C.L. Koch, 1837 is represented by two species, *Buthus occitanus* (Amoreux, 1789) (88.5 %) and *Buthacus arenicola* (Simon, 1885) (7 %). The family of Scorpionidae Latreille, 1802 is represented by *Scorpio maurus* Linnaeus, 1758 (4.5). These results are showed in Table 1.

The results of the figure 2 allowed to draw a factorial analysis of correspondences (AFC) by using the software XLSTAT (2014).

This AFC illustrates the groupings of the scorpion fauna as well as their interactions with the stations in the study area (Fig. 1).

The examination of this graph shows two relatively heterogeneous groups in both factorial axes; the analysis of the Table 2 shows that the rate of the slowness of the axis 1 is higher than the rate of the slowness of the axis 2 which means that the projection is mainly made on the first axis.

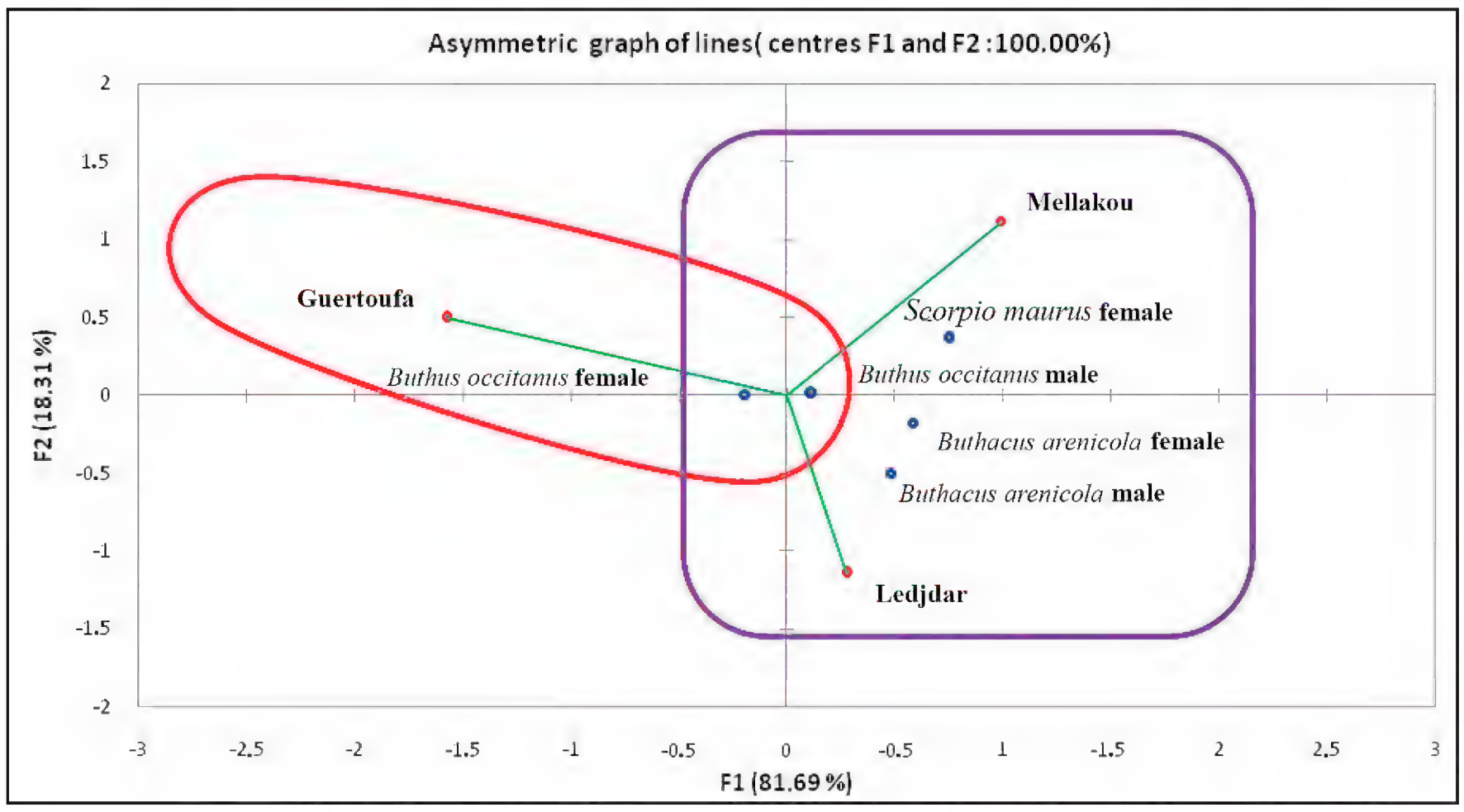

Fig. 2. Factorial Plan of stations according to species.

According to the projection F1-F2, the axis F1 represents 81, 86 of the slowness. In the same vein, we noticed that the positive side towards the extremity of the axis becomes a group in the region that includes Mellakou and Ledjdar stations with *B. occitanus* (males and females), *B. arenicola* (males and females) and *S. maurus* (females). On the negative side, at the end of the axis becomes more groups in the region that constituted the station Guertoufa with *Buthus occitanus*. In the center of the factorial plan, we have the formation of a bubble made up of a species met in all the stations of the study, especially *Buthus occitanus* (males and females).

The factorial analysis of the correspondences applied on the species captured in the region of Tiaret, allowed us to notice that *B. occitanus* is close to the center of the graph and in both sides, being present in the three stations of the study area.

These results are conform to the works of El Hennawy (1992) who reported for this species a large distribution in North Algeria. The two other species, *S. maurus* and *B. arenicola*, are uniquely found in two stations; the station of Mellakou and the station of Ledjdar, but are completely absent in the third station of Guertoufa (anthropized area).

Morphometry and description of the inventoried species

Buthus occitanus. The morphometry of *B. occitanus* is illustrated in the figure 2. The length of *B. occitanus* is 64±8.54 mm. This measure gets closer to that indicated by Boué & Chanton (1974) of 7.5 cm length. The length and width of femur are, respectively, 6.39±0.96 mm and 1.94±0.39 mm, while of the patella are, respectively, 5.00±0.86 mm and 1.43±0.28 mm. The length and the width of the chela are, respectively, of 10.64±1.54 mm and 3.03±0.67 mm.

The mobile finger has length of 7.33±1.21mm, and the gland with poison is 6.15 ± 0.98 mm. The body has a yellow color, darker than the appendixes.The tail has the presence of silks. *B. occitanus* is the most plentiful in comparison with the other two species. In the three stations it has the rate of 88.5 %. This is a greater rate than the one studied by Sadine et al. (2011) in the park of Belezma in North Algeria (82.5 %).

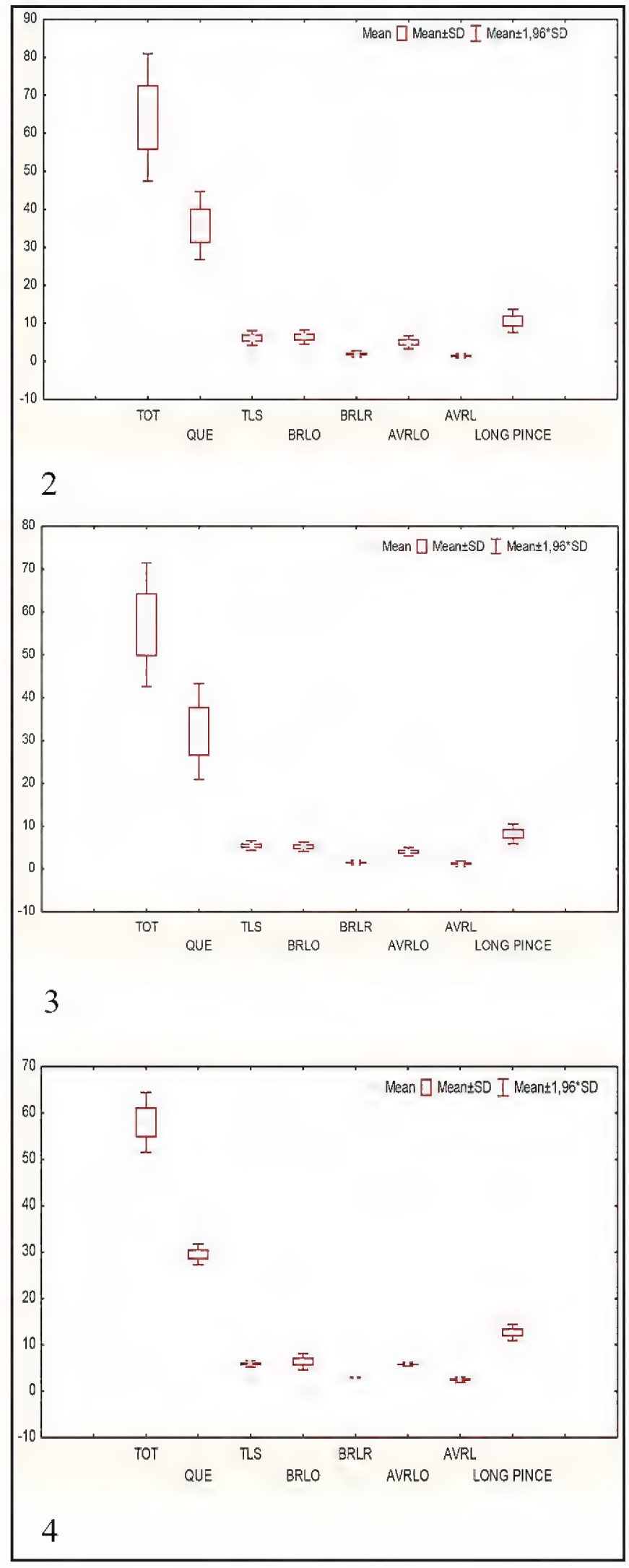

Figure 2. Morphometry of *Buthus occitanus*.
Figure 3. Morphometry of *Buthacus arenicola*.
Figure 4. Morphometry of *Scorpio maurus*.
TOT: total length, TLS: length of the vesicle with poison, QUE : length of the tail, BRLO: length of the femur, BRLR: width of the femur, AVRLO: length of the patella, AVRL: width of the patella, LONG PINCE : length of the chela.

Buthus occitanus is widespread in Africa, Asia and Europe (Lourenço & Vachon, 2004). Lourenço (2002) mentioned that the colonization of Europe by this species was made, probably, through the coastal regions of Morocco. Lourenço & Vachon (2004) observed that *B. occitanus* collected in the Sierra Nevada would be originally from the region of North Africa. Gantenbein & Largiadèr (2003) noted that the specimens of Europe are very different from that of those found in North Africa.

<u>*Buthacus arenicola.*</u> The figure 3 shows the morphometry of *B. arenicola*. The length of this species is 57.04±7.36 mm. The femur is long 5.18±0.54 mm and it is wide 1.48±0.24 mm. The patella is long 4.00±0.50 mm and it is wide 1.21 0.31 mm. The length of the finger is 8.18 ± 1.17 mm and it is wide 2.27±0.49 mm. The measures of the chela found in our study are conform with the findings of Lourenço (2006) who has indicated that *B. arenicola* has a thin chela. The length of the mobile finger is 5.77 ± 0.64 while the length of the gland with poison is 5.44 ± 0.56 mm. The body of the specimens is brown. The tail is wide and has a dark yellow color, the vesicle with poison is smaller than that of *B. occitanus* and it has very thin yellow pedipalps with several silks.

This species is less common than the *B. occitanus*, and its presence was indicated only in two stations, Ledjdar and Mellakou (7 %). According to Lourenço & Leguin (2014), the distribution of *B. arenicola* extends from western Libya to Tunisia to northen Algeria. Vachon (1952) discussed the large distribution of the *Buthacus* genus and also expressed his doubts about the real taxonomic status of the various population of *B. arenicola* found in North and Northwest of Africa. Sadine et al. (2011) observed this scorpion in the region of Ouargla in South Algeria. *Buthacus arenicola* is present in opened spaces such as Ergs, Regs or agricultural fields of sand (Lourenço et al., 2017).

<u>*Scorpio maurus.*</u> The morphometry of the *S. maurus* is illustrated in figure 4. The length of this species is 57.99 3.28 mm. The length and width of the femur are, respectively, 6.39 0.90 mm and 2.94 ± 0.03 mm. Those of the patella are, respectively, 5.08±0.17 mm and 2.47 0.29 mm. The chela is 12.67 ± 0.89 mm long and it is 5.23 0.64 mm wide. Vachon (1952) has reported that, in Algeria and Tunisia, scorpions with wide chela are always *S. maurus*. The length of mobile finger is 7.56 ± 1.06 mm while that of the gland with poison is 9.90 ± 0.32 mm. The body is dark brown with a thin tail and clearer legs. Chelicerae are striking and darkened. Pedipalps are brown, large and strong, and become more darkened in the extremities. This species is known for its capacity to live in high altitude, and it lives, normally, in the hot environments (Mozaffari et al., 2013). Fet (2000) confirmed its presence in Algeria.

Scorpio maurus is less plentiful regarding the two other species cited above, its presence rate is 4.5 %, and it was found in only two stations, Ledjdar and Mellakou. This rate is lower than the one registered by Sadine et al. (2011), which was 15.5 % in the park of Belezmain, North Algeria.

CONCLUSIONS

This study on the scorpions fauna, carried out in the region of Tiaret West Algeria, allowed us to

Stations	Ledjdar		Mellakou		Guertoufa		Total
sex	Male	Female	Male	Female	Male	Female	
Buthus occitanus	27	45	22	29	14	40	**177**
Buthacus arenicola	05	04	02	03	/	/	**14**
Scorpio maurus	/	03	/	06	/	/	**09**
Total by sex	32	52	24	38	14	40	**200**
Total	**84**		**62**		**54**		**200**

Table 1. Enumeration of the species inventoried by stations in Tiaret region (Algeria).

	F1	F2
Appropriate Values	70	0.016
Slowness (%)	81.686	18.314
% accumulated	81.686	100.000

Table 2. Appropriate Values and percentages of slowness of both axes of the AFC.

identify the Buthidae family represented by two species, *B. occitanus* (88.5% presence rate), and *Buthacus arenicola* (7%) and the Scorpionidae family with the *S. maurus* (4.5%).

The Factorial Analysis of the Correspondences (AFC) reveals that the *B. occitanus* is the species more common in the three stations of study area. *Buthacus arenicola* and *S. maurus* are found only in the stations of Ledjdar and Mellakou, but *Scorpio maurus* is less plentiful.

The morphometry of the species shows that *Buthus occitanus* has the chela 3.03 ± 0.67 mm wide, *B. arenicola* is characterized by a thin pedipalps and chela is 2.27 ± 0.49 mm wide. *Scorpio maurus* is characterized by its wide and strong pedipalps and with a large chela (5.23 0.64 mm wide).

Further studies on these faunas, carried out also in larger territories and with a greater number of stations, will be able to further improve the knowledge on this interesting group of terrestrial invertebrates.

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Presence of the alien species *Godiva quadricolor* (Barnard, 1927) (Gastropoda Nudibranchia Facelinidae) along the coast of eastern Sicily

Andrea Lombardo & Giuliana Marletta

Department of Biological, Geological and Environmental Sciences - Section of Animal Biology, University of Catania, via Androne 81, 95124 Catania, Italy
Corresponding author, e-mail: andylombardo94@gmail.com

ABSTRACT This work explores the second report of the alien nudibranch *Godiva quadricolor* (Barnard, 1927) (Gastropoda Nudibranchia Facelinidae) in eastern Sicily (Italy). Previously, this species has been found only in the area of Faro Lake (Messina), where now there is a significant population. The specimen here reported was sighted while diving in Santa Maria La Scala (Acireale, Catania) near a fresh water source. In fact, as it has been claimed by other authors, there is a strong correlation between this species and the brackish water areas. This work argues that this specimen has been brought to this area either by the Strait of Messina currents or by fishing boats, which dock at a small port in the study area. Since this is a species which easily adapts to different environmental conditions and feeds on other nudibranchs, *G. quadricolor* propagation could be a great threat to indigenous biodiversity.

KEY WORDS Alien species; Gastropoda; *Godiva quadricolor*; nudibranch; Sicily.

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INTRODUCTION

Godiva quadricolor (Barnard, 1927) is a nudibranch (Gastropoda Nudibranchia Facelinidae) discovered in the area of False Bay, in South Africa. During the last century this species has been found in different tropical and temperate waters of the world: Mozambique (Macnae, 1954), Tanzania (Willan, 2004), Ghana (Edmunds, 1977), Australia (Willan, 1987), Morocco (Atlantic Ocean) and the Strait of Gibraltar (Cervera et al., 2010). In the Mediterranean Sea, apart from the Strait of Gibraltar (Bay of Algeciras), this nudibranch has been reported also along the coasts of France (Étang de Thau) (Crocetta & Malegue in Gerovasileiou et al., 2017) and in several coasts of Italy: in the Fusaro lake in the Gulf of Naples (Cattaneo-Vietti et al., 1990), in the Sabaudia lake near Latina (Macali et al., 2013), at Noli in the Ligurian Sea (Betti et al., 2015), in the North Adriatic, among the coasts of Ravenna (Zenetos et al., 2016), and in the Faro lake in Sicily (Furfaro et al., 2018). In the coasts of Noli and Ravenna this species appeared only temporary (Betti et al., 2015; Zenetos et al., 2016), while in the lakes of Fusaro and Faro *G. quadricolor* still forms stable populations (Villani & Martinez, 1993; Furfaro et al., 2018). In both cases, the lakes are connected to the sea and consequently these populations live in brackish water areas.

G. quadricolor is a marine species which can settle in brackish water areas and adapt to a great variety of environmental conditions, especially for what concerns temperature and salinity. This organism lives in both temperate and tropical waters, proving that it is a euriecia species. Moreover, since this species has been detected in anthropized coasts with a significant marine traffic, it has been claimed that the alien *G. quadricolor* was brought to the Mediterranean Sea by ballast waters (Willan, 2004; Cervera et al., 2010). Native of the Indian Ocean and now common also in South African coasts, this species has penetrated in the Mediterranean Sea through either the Strait of Gibraltar or the Suez Channel, because of surface water warming (Trainito & Doneddu, 2014; Betti et al., 2015).

MATERIAL AND METHODS

The Timpa is a big coastal slope in the Ionic coast of Sicily (Italy), which belongs to the town of Acireale. It hosts a rich natural heritage, both marine and terrestrial. In particular, the specimen has been found in the area of a spring called "Testa dell'acqua", which used to feed a XVI century mill, in Santa Maria La Scala (37°37'2"N, 15° 10'20"E). In general, the area of Timpa shows several springs that determine the flow of fresh water from Mount Etna to the sea (Ferrara, 1977; Catra et al., 2006). The sea floor where the animal was found is characterized by boulders and rocks of variable size, formed after the erosive activity of the sea.

Figure 1. The *Godiva quadricolor* specimen found in Santa Maria La Scala (Sicily, Italy). Photo by A. Lombardo.

The *G. quadricolor* specimen was photographed with an Olympus TG4 underwater camera.

RESULTS

On 23rd November 2018, a small *G. quadricolor* specimen was found under a stone at 7 mt depth, while diving in Santa Maria La Scala (Acireale, Catania, Italy). The animal was photographed and identified "in vivo" (Fig. 1). It showed all the external morphological features reported in Bernard's original description (1927): wrinkled rhinophores; a white line going from the base of each rhinophores to the base of its corresponding oral tentacles; a slender body with a predominance of white; cerata with a specific pattern (blue ring, brown ring, orange ring, brown ring, blue ring, etc.); white-cream upper parts. As regards its behaviour, the nudibranch avoided the sunlight in search of darker areas: this could demonstrate that it is a shade-lover.

CONCLUSIONS

This is the second report in Sicily, after that in Faro Lake (Furfaro et al., 2018). Since in the area of Messina there is a significant population of *G. quadricolor* (Furfaro et al., 2018), this work claims that the found specimen could have been taken in veliger stage through the Strait of Messina currents. Otherwise, since Santa Maria La Scala hosts a small port, that veliger of *G. quadricolor* could have travelled attached to the keel of some fishing boats. Moreover, the specimen was in a coastal area, like that of Noli (Betti et al., 2015), but influenced by fresh waters (Ferrara, 1977; Catra et al., 2006), as it has been previously highlighted.

This finding confirms the great adaptability of this species to different environmental conditions, especially for what concerns temperature and salinity. Moreover, it testifies that this species is spreading quickly in the Mediterranean Sea, where the first report in Fusaro Lake dates back to 1985 (Cattaneo-Vietti et al., 1990). Since it is a voracious nudibranchs predator (Gosliner, 1987), it could become a threat to indigenous nudibranchs fauna and a danger to biodiversity.

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Digenean parasites in two congeneric sparid fishes and of commercial importance, *Pagellus erythrinus* (Linnaeus, 1758) and *Pagellus acarne* (Risso, 1827), from the western Mediterranean coast of Algeria

Sihem Abid-Kachour, Omar Rouane Hacene, Salim Mouffok & Mohammed Bouderbala

University of Oran 1 Ahmed Ben Bella, Laboratoire Réseau de Surveillance Environnementale (LRSE), Department of Biology, BP 1524 El M'naouer, 31000 Oran, Algeria
*Corresponding Author, email: sihemabid@yahoo.fr

ABSTRACT The investigation into the digenean fauna of two congeneric sparid fishes (Perciformes Sparidae), *Pagellus erythrinus* (Linnaeus, 1758) and *Pagellus acarne* (Risso, 1827), was carried out in the Algerian coasts (Western Mediterranean). These fishes of commercial importance represent an important biological resource for the human population along the Mediterranean coasts. However, the data on their digenean parasites in Algeria are incomplete and the aim of this study is to provide new data on the diversity and species composition of digeneans from these hosts. A total of 240 fishs (120 of each species) were collected from Oran (Northwestern Algeria) during 12 months between September 2016 and August 2017. Eleven species of digeneans were found in the two fish hosts: (i) *Lepocreadium pegorchis* (Lepocreadiidae); *Lepocreadium album* (Lepocreadiidae); *Holorchis pychnoporus* (Lepocreadiidae); *Holorchis spp* (Lepocreadiidae); *Hemiurus comminus* (Hemiuridae); *Hemiurus luehei* (Hemiuridae); *Lepidauchen stenostoma* (Acanthocolpidae) and *Pachycreadium carnosum* (Opecoelidae); *Macvicaria crassigula* (Opecoelidae) in *Pagellus erythrinus*; (ii) *Lepocreadium pegorchis* (Lepocreadiidae); *Macvicaria crassigula* (Opecoelidae); *Zoogonus spp* (Zoogonidae) and *Hemiurus communis* (Hemiuridae) in *Pagellus acarne*. In the evaluation of the dynamics of the epidemiological index of the community of digenean parasites, two species of fish show seasonal variations. Furthermore, higher prevalence of infestation were registered during the summer season for the Opecaelidae family in the two hosts.

KEY WORDS Sparidae; *Pagellus*; congeneric; Digenean; epidemiological index; Algerian coasts.

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INTRODUCTION

Through this study we have identified and compared the digenean endoparasites of two congeneric sympatric sparid fishes (Perciformes Sparidae), which are also of great commercial importance, *Pagellus erythrinus* (Linnaeus, 1758) and *Pagellus acarne* (Risso, 1827). The study area was the west coast of Algeria. This approach is an attempt to highlight the influence of biotic and abiotic factors in structuring the community of digenean parasites. Indeed, the niches of parasite species are strongly influenced by the environment, particularly the quality of the food resources and

their abundance (Price & Clancy, 1983; Bates & Kennedy, 1990; Holmes, 1990; Holmes & Bartoli, 1993). Some authors (Holmes, 1973; Pianka, 1974; Rohde, 1979) suggest that interspecific and intraspecific competition between sympatric host species favor niche restriction for the parasite. A morpho-anatomical study has been carried out to put the digeneans collected from each host in their taxonomic context and a quantitative and qualitative study was carried out in order to compare the community of the digeneans in both congeneric sparid fishes. The digenean fauna of sparid fish has been the subject of various studies in the Mediterranean Sea, among them we will cite the works of: Bartoli, 1987a, 1987b; Bartoli & Gibson, 1989; Bartoli et al., 1989a, 1989b; 2005; Saad-Fares & Maillard, 1990; Bartoli & Bray, 1996; Sasal et al., 1999; Kostadinova & Gibson, 2009; Sanchez et al., 2013, 2014. Moreover, we can also mention recent works undertaken on the parasitofauna of sparidae fishes in the Mediterranean Sea, including the work of Merzoug et al., 2012; Abid Kachour et al., 2013; Antar & Gargouri Ben Abdallah, 2013; Abid Kachour, 2014; Antar et al., 2015; Bellal et al., 2016. However, this contribution is still incomplete, knowing that sparidae are considered as ideal host fish for the larval and adult stages. The biodiverty of the community of the digenean parasites within each host will allow us to highlight their trophic ecology (Brooks & Hoberg, 2000; Khan & Chandra, 2006).

MATERIAL AND METHODS

A total of 240 fishes (120 of each species) from Oran's coasts, north western Algeria (Fig. 1) during the 12 months between September 2016 and 2017, have been sampled. The digeneans found in digestive tract of *Pagellus erythrinus* and *P. acarne* have been set into alcohol of 70%, put for some minutes in Borax Carmine solution (Grenacher) and after in chlorhydric acid, dehydrated in successive baths of alcohol of 70, 85, 95%, then in two baths of absolute ethanol 100%. They have been cleared in Eugenol and mounted in Canada balsam. All the parasitic digenans harvested in this study were identified with taxonomic keys (Yamaguti, 1934 ; Gibson et al., 2002). The different ecological terms used for digenean communities (prevalence, mean intensity and abundance) were calculated as described by Bush et al. (1997).

Terms used as "dominant species" (prevalence> 50%), "satellite species" or common (prevalence 10%-50%) and "rare species" (prevalence <10%) were defined according to Valtonen et al. (1997). Statistical analysis was performed using the STA-

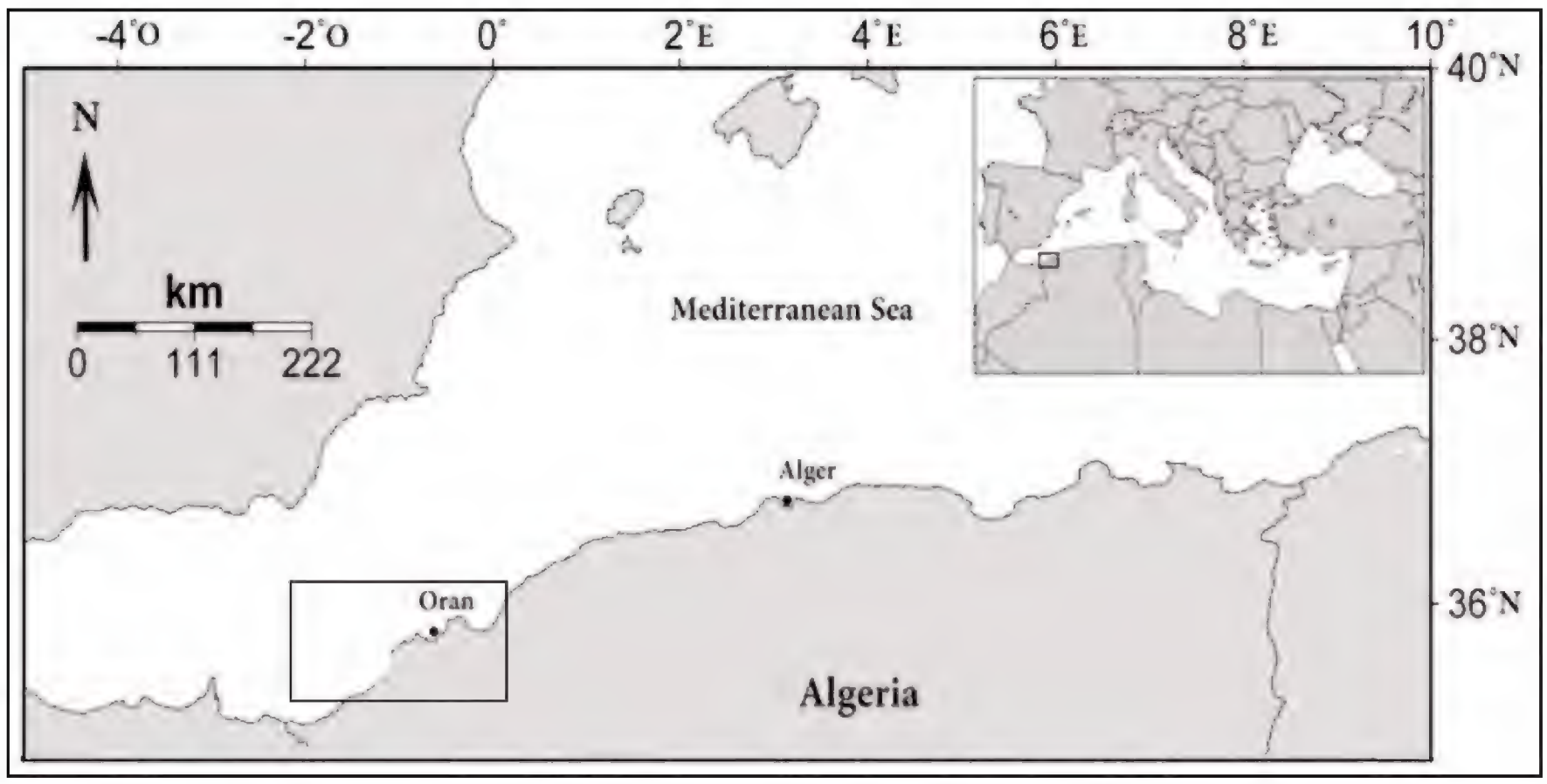

Figure 1. Study area: Oran's coasts, north western Algeria.

TISTICA software (Statsoft statistica version 12.5.192.7).

RESULTS

The two host fishes of this study have in their digestive system a large and variable number of digeneans belonging to different families. However, the composition of the digenean community does not evolve in the same direction in two host fishes and show differences with the seasons. A total of 11 digenean species belonging to 4 families have been identified (Table 1).

In *P. erythrinus*, the family Opecoelidae was dominant, largely represented by the species *Macvi-*

Species	Families	Site(s)	Prevalence	Abundance	Mean Intensity
Pagellus erythrinus **N=120**					
Lepocreadium pegorchis (Stossich, 1901)	Lepocreadiidae	CD	33.33	0.5	1.5
Lepocredium album (Stossich, 1890)	Lepocreadiidae	CD	25	0.33	1.33
Holorchis pycnoporus (Stossich, 1901)	Lepocreadiidae	CDE	7.5	0.09	1.22
Holorchis sp.	Lepocreadiidae	CD	3.33	0.04	1.25
Macvicaria crassigula (Linton, 1910)	Opecoelidae	CD	41.66	0.56	1.36
Pachycreadium carnosum (Rudolphi, 1819)	Opecoelidae	CD	51.66	0.58	1.12
Hemiurus communis Odhner, 1905	Hemiuridae	A	8.33	0.09	1.1
Hemiurus luehei Odhner, 1905	Hemiuridae	AD	3.33	0.04	1.25
Lepidauchen stenostoma Nicoll, 1913	Acanthocolpidae		4.16	0.04	1
Pagellus acarne **n=120**					
Lepocreadium pegorchis (Stossich, 1901)	Lepocreadiidae	CB	25	0.33	1.33
Macvicaria crassigula (Linton, 1910)	Opecoelidae	CD	29.16	0.33	1.14
Zoogonus sp.	Zoogonidae	F	17.5	0.20	1.19
Hemiurus communis Odhner, 1905	Hemiuridae	A	3.33	0.04	1.25

Table. 1. Parasitological indices for digeneans from two Sparid fishes off the western Mediterranean coast of Algeria. Sites: A, stomach; B, pyloric caeca; C, duodenum; D, mid-intestine; E, posterior intestine; F, rectum.

caria crassigula (51.66%) occupying a large part of the intestine, followed by *Pachycreadium carnosum* found in the duodenum and mid-intestine (25%). The family Lepocreadiidae is represented by *Lepocreadium pegorchis* (41.66%), *L. album* (33.33%), found at the duodenum and mid-intestine levels, *Holorchis pycnoporus* (7.5 %), and *H.* sp. (3.33%) both collected in the duodenum, mid-intestine and rectum. *Hemiurus communis* (8.33%) and *H. luehei* (3.33%), are species belonging to the family Hemiuridae. They are rare and were all found at the stomach level. The family Acanthocolpidae was marked by the presence of *Lepidauchen stenostoma* in the duodenum with a prevalence of 3.33%. For *P. acarne*, we recorded the presence on the intestinal level of the species *Lepocreadium pegorchis* (Lepocreadiidae) with a prevalence of 25 %. *Macvicaria crassigula* (Opeceolidae) was recorded in the duodenal part (29%) and mid internal (16%), *Zoogonus* sp. (Zoogonidae) on the anus level (17.5%), and *Hemiurus communis* (Hemiuridae) was found in the stomach (3.33%).

Concerning the ecological aspect, we noted that the community of digenean parasites of two host fishes (*P. erythrinus* and *P. acarne*) varies according to the seasons. The strongest values of prevalence of some species were observed in summer. The histogram of seasonal variations for *P. erythrinus* (Fig. 2) shows that the prevalence of parasitic species varies with a minimum rate of 3.33 in winter up to at 83.33% in summer.

This variation concerns, in particular, *Macvigaria crassigula*, in which we observed a prevalence of 26.66% in winter, a clear progression from spring, reaching its maximum in summer (83.33%) while a decrease is recorded during the autumn (Fig. 2). *Pachycredium carnosum* also showed a significant rate of parasitism for the summer period of about 66.66%. The family of Lepocreadiidae is especially represented by *Lepocreadium* genus, also frequent during the summer. We did not find any significant seasonal change for other digenean parasites (Fig. 2). We recorded variations of digenean fauna according to the change of seasons also in *P. acarne* (Fig. 3). *Macvicaria crassigula* is prevalent with 3.33% in winter, reaching 73.33% in summer period. *Lepocreadium pegorchis* (70%) and *Zoogonus* sp. (50%) are prevalent too during the summer, while no change of the prevalence according to the seasons was observed for *Hemiurus communis*.

DISCUSSION

Through these results, we found that the structure of the digenean community was not completely identical and homogeneous in both the host fishes. These two sparidae belong to the same genus. They are very close phylogenetically and sharing the same biotope and food habits (Bauchot et al., 1990) can determine the infestation of the

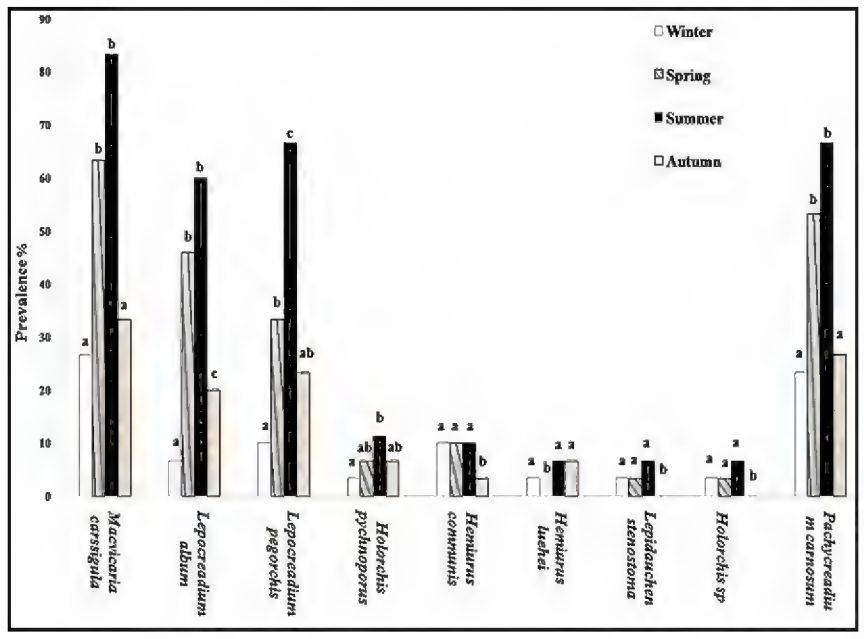

Figure 2. Comparative study of the variances of parasitic species according to the seasons in *Pagellus erythrinus*. Data with different letters expressed significant differences between seasons ($p < 0.05$) for each species of parasitic digenean.

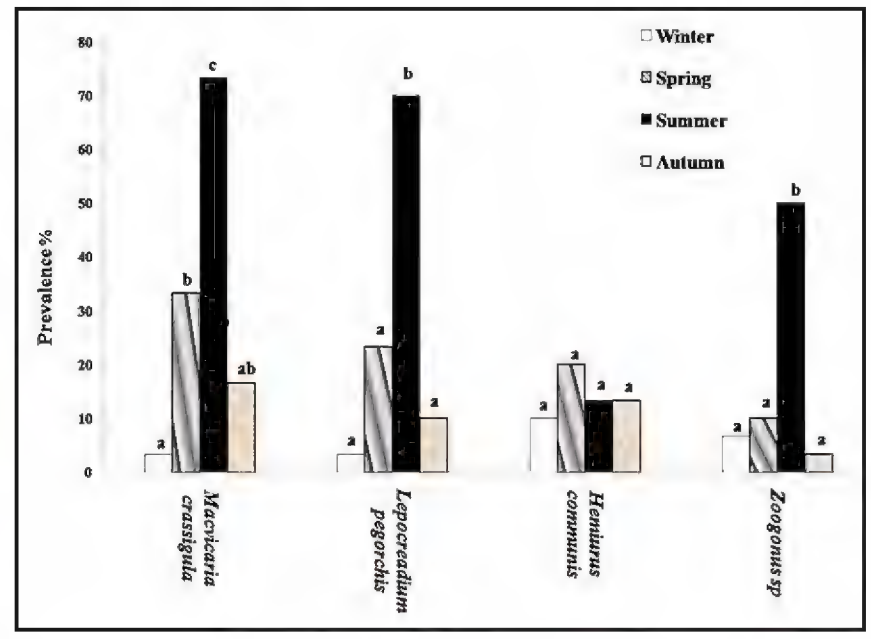

Figure 3. Comparative study of the variances of parasitic species according to the seasons in *Pagellus acarne*. Data with different letters expressed significant differences between seasons ($p < 0.05$) for each species of parasitic digenean.

larval stages of the digenean species by trophic way (Morand, 1996). Indeed, these two congeneric sparidae nourish mainly on shellfish and molluscs, generally the first and second intermediary hosts of the majority of the digenean species. Despite all these convergences, the digenean community in *P. erythrinus* was both important and richer compared to that of *P. acarne*. This difference may be the result of trophic competition between congeners. Indeed, some studies suggest that competition for a resource such as food may be more intense between closely related host species (Harmelin-Vivien et al., 1989; Sala & Ballesteros, 1997; Azzurro et al., 2007). However, we found that some digenean species such as *Macvicaria crassigula* (Opeceolidae) and *Lepocreadium pegorchi*s (Lepocreadiidae) were recorded in both host fishes in the same microbiotope with a high prevalence, giving them the rank of dominant and generalist parasite (Sasal et al., 1999). These species have already been reported several times in sparidae, notably in *P. erythrinus* in the Mediterranean Sea (Bartoli et al., 2005; Antar & Gargouri, 2013). This specificity is qualified strictly from a coevolutive adaptation (Brooks & Hoberg, 2000). In addition, many authors have hypothesized that the parasite's preferential microbiotope is the result of the influence of immune host responses (Holmes, 1990; Holmes & Bartoli, 1993). Others support the theory of the influence of the trophic network (Bartoli et al., 2005). Various studies also show that parasite populations will fluctuate within their hosts depending on the surrounding environmental conditions (Khan & Chandra, 2006). We also found that the rate of infestation was lower at the stomach level, compared to the intestine. These results concur with the hypothesis proposed by several authors in which they suggest that the stomach remains a hostile environment because of its chemical and physical contribution (Holmes, 1990).

Concerning the variations of parasite prevalence according to the seasons, and after use of the statistical test, the impact of the temperature is not similar for all the digenean species resumed in the two host fishes. However, some digeneans show a significant difference in their prevalence with a consequent increase during the summer period, these results coincide with those obtained by Desclaux (2003). *Macvicaria crassicula* (Opecoelidae) and *Lepocredium pegorchis* (Lepocreadiidae), hosted by both *Pagellus*, present this specificity in relation to the seasons. Indeed, if one refers to the work already done on the fluctuations of the parasite abundance of different taxa, especially the digeneans, according to the changes of seasons, show that the various factors, like the increase of the temperature or the salinity can alter the specificity of parasites (Williams et al., 1994; Sasal et al., 1997). However, in certain digenean parasites the increase of the temperature during the summer favors their pululation (De Kinkelin, 1971). Recently, studies have confirmed the effect of light and temperature on their determining role in the emission of digeneans (Desclaux, 2003). With regard to parasites that show no significant variation with the seasons, as is the case for *Hemiurus communis* (Hemiuridae), a generalist species, some studies are concerned with temperature, an environmental parameter involved in the inhibition or reduction of the emission of certain cercariae in the first intermediate host gastropods, thus disturbing the evolutionary cycle of a given species (Prévot, 1974, Williams & Jones, 1994). In addition, the trophic behavior of the two host fishes (*P. erythrinus* and *P. acarne*) changes with the seasons (Bauchot et al., 1990; Fanelli et al., 2011).

CONCLUSIONS

We notice in this study that the composition of the community of digenean parasites of these two sympatric and congeneric host species does not systematically exhibit the same digenean structure in terms of quantity and quality and does not respond with the same variations in prevalence in according to the seasons. Except for some dominant and common species as is the case of *Macvicaria crassigula* and *Lepocreadium pegorchis*, the results were similar in both host fishes. Indeed, these results corroborate the work of some authors such as Poulin (2002) and Sasal & Thomas (2005) and who suggest that host fish sharing the same biotope could develop a parasite exchange between them. However, divergences in the results of digenean species in both sparidae, as mentioned by some authors such as Bartoli (1987b) and Bartoli et al. (2005), are related to the food web and partitioning available to both host fishes. More-

over, our results respond mainly to the competition theory that exists between parasitic species: when one species colonizes a host, it prevents the eventual installation of the other (Sasal & Thomas, 2005).

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The reproduction cycle of the sea cucumber *Holothuria* (*Holothuria*) *tubulosa* Gmelin, 1791 (Echinodermata Holothuroidea Holothuriidae) in Oran coast, Algeria

Yamina Tahri*, Saliha Dermeche, Fayçal Chahrour & Mohammed Bouderbala

Laboratoire Réseau de Surveillance Environnementale (L.R.S.E), Département de Biologie, Faculté des Sciences de la Nature et de la Vie, Université d'Oran 1 Ahmed Ben Bella Oran, 31000 Algeria; e-mail: salydermeche@gmail.com, fayalchahrour@gmail.com, mohammedbouderbala2016@gmail.com

*Corresponding author, e-mail: tahriamina76@gmail.com

ABSTRACT

The aim of this paper is to present an analytical study of gonad index (GI) and repletion index (RI) of *Holothuria* (*Holothuria*) *tubulosa* Gmelin, 1791 (Echinodermata Holothuroidea Holothuriidae). The study is based on biomonitoring data collected from February 2014 to January 2015 in the Oran coast. The gonad index of *Holothuria tubulosa* is analyzed to show the reproductive cycle and its relationship to environmental parameter conditions. Samples of 15 to 20 individuals were collected monthly at three stations on the Oran coast (La Madrague, Cap Carbon, and Ain Franin). The sex ratio of all sampling was found as (female: male) 0.8:1.2 with no significant difference between sites (X_2= 2.18 ; df=4 ; p>0.05) and is also not significant regarding the seasons (spring, summer, autumn, winter) (X2= 3.03 ; df=6 ; p>0.05). Sea cucumber reproduction occurred in September at Cap Carbon and Ain Franin with values of Gonad index (GI) that are 0.33± 0.52 % and 0.22± 0.52 % respectively. At the La Madrague site, the spawning occurred in October with a value of GI of 1.49±2.03 %. It was observed that seawater temperature has a positive correlation with Gonad index (GI) and no correlation with Repletion index (RI).

KEY WORDS

Gonad index; *Holothuria tubulosa*; Oran coast; sex ratio; seawater temperature.

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INTRODUCTION

The aspidochirote *Holothuria* (*Holothuria*) *tubulosa* (Gmelin, 1788) (Echinodermata Holothuroidea Holothuriidae) is widely distributed in the Mediterranean Sea (Francour, 1990; Coulon & Jangoux, 1993a; Koukouras et al., 2007) where it is an important part of the macrozoobenthos (Mezali et al., 2006; Costa et al., 2014). It lives on rocky substrata, loose sediments, and in sea grass meadows at depths varying between 5 and 100 meters (Ocaña & Tocino, 2005). *Holothuria tubulosa* is a common species on the Algerian seabed (Mezali, 2008). It is an ecologically important species because of its role in the recycling of organic matter in *Posidonia oceanica* (L.) Delile meadows (Costa et al., 2014) and its stabilization of the bacterial community in the sediments (Amon & Herndl, 1991).

Holothurians have lost pentamerism in their reproductive system (Navarro et al., 2012) and have a single gonad composed of one or two tufts of tubules (Conand, 1989). The gametes are released into the water through gonopore located at the dorsal mesentery (Pérez-Ruzafa, 1984; Conand, 1989).

The gonads tend to fill most of the interior cavity of the body at their peak maturity stage (Pérez-Ruzafa, 1984). In general, holothurians have a seasonal reproductive cycle (Smiley et al., 1991). However, whilst temperate species generally have spawning periods in spring and summer (Cameron & Fankboner, 1986; McEuen & Chia, 1991; Hamel et al., 1993), tropical species may spawn throughout the year (Pearse, 1968; Conand, 1993a; González et al., 2004).

A number of environmental factors may stimulate gonad growth, maturation, and spawning (Fenaux, 1980). For example, sea temperature is an important factor that influences spawning (Fuji, 1960) and the inhibition or slowing down of nutrition (Smith, 1971).

In Algeria, there are few studies on sea cucumbers and their spawning. In this study, we will follow the gonad index and repletion index (reproduction and trophic activity) and the influence of environmental factors on the spawning of the *H. tubulosa* population sampled at three sites on the west coast of Algeria with different locations and substrates.

MATERIAL AND METHODS

Study area

The study was conducted on the Oran coast, in the northwest of Algeria. Three sites were selected. Station 1, La Madrague, 35°46'00.58''N - 0° 49'33.00'' W is located on the west of Cape Falcon, and is a rocky site forming a large bay open to the east. Upstream of this coastal site there are farms that are part of the National Plan of Agricultural Development (PNDA). These farms may affect the coastal marine ecosystem through the use of pesticides, fertilizers and phytosanitary products (Benghali et al., 2006). Station 2, Ain Franin, 00°35'46'854''N - 30°768'00''W is located between two headlands forming the large bay of Oran, Cape Ferrat to the north and Cape Falcon to the southeast and 8 km far from Kristel. This station is considered as a low-impact anthropogenic area, but there is presence of a source of sulfuric thermal water. Finally, station 3, Cap Carbon, 35° 54' 6.36''N - 0° 20'20.22'' W is located near the agglomeration of Arzew. This area is under significant influence of urban and industrial discharges from the presence of a petrochemical industrial complex (Arzew-Ain El Bia, Oran) as shown in figure 1.

Field Sampling

The study is based on 12 sampling months from February 2014 to January 2015. From 15 to 20 sea cucumbers were collected each month by scuba divers at a depth of up to 10 m, at the three study areas. Temperature, salinity, and pH of the surface water were measured using a Multiparameter (HANNA–HI9829) instrument. At the laboratory, each animal was dissected along the ventral surface and eviscerated. The gonads and the digestive tract (intestine and digestive contents) were recovered, drained and weighed with electronic scales (0.001 g precision). All gonads were fixed in 10% formalin for microscopic observations using Microscope: Leica DM 2000. The mean Gonad (GI) and mean Repletion indexes (RI) were calculated using the ratio between the gonad weight or intestine weight (GW, IntW) and the total weight of the gutted body (GBW) by the formula (Asha & Muthiah, 2008; Gaudron et al., 2008; Kohler et al., 2009).

Figure 1. Study area: Oran coast, NW-Algeria.

$$Gonad\ index\ (GI) = \frac{GW}{GBW} \times 100$$

$$Repletion\ index\ (RI) = \frac{IntW}{GBW} \times 100$$

Data analysis

The collected data are computed and analyzed with IBM SPSS 20 software. The sex ratio study was tested by chi-square. The differences in both indexes (GI and RI) between sites, months and seasons were tested through a one-factor ANOVA test and the Tukey test. The relations between GI, RI and environmental factors were determined using the Pearson Correlation Analysis.

RESULTS

By using the macroscopic and microscopic observations, the gonads of 640 *H. tubulosa* were sexed as 321 females, 259 males, and 60 unidentified individuals. The sex ratio (female:male) is 0.8:1.2. The sex ratio at La Madrague (female:male) is 1.25:0.79, at Cap Carbon is 1.2:0.83 and at Ain Franin is 1.27:0.78. By chi-square test, the difference in sex ratio compared to sites is not significant (X_2=2.18; df=4; p>0.05) and also not significant compared to the seasons (spring, summer, autumn, winter) (X2= 3.03; df=6; p>0.05) (Table 1).

The study was performed on 640 samples collected during sampling campaign. The collected samples allowed us to determine the changes in the Repletion index (RI) and the Gonad index (GI). The averages of repletion and gonad indexes are characterized by a monthly change which is greater for the repletion index (Table 2).

The monthly average repletion index gives the most variations which were the maximum 76.56± 14.13 % in October and the minimum 31.47± 20.95 % in September at Cap Carbon. For the Ain Franin site the maximum is 97.67±21.26 % in March and the minimum is 22.55±6.22 % in September (Fig. 2). For the La Madrague site, the repletion index is different from the previous sites, the minimum is 20.97±6.40 % in February and the maximum is 81.77±13.47 % in October (Fig. 2).

	Chi-square X_2	*df*	*P*
sites	2.18	4	0.702
seasons	3.03	6	0.805

Table 1. The difference in sex ratio compared to sites and seasons by Test Chi-square.

Area		*Feb 2014*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Agu*	*Sep*	*Oct*	*Nov*	*Dec*	*Jan 2015*
MA	*GI*	0.94 (0.56)	1.26 (0.44)	3.58 (2.15)	1.69 (1.11)	16.27 (8.32)	15.86 (8.40)	22.85 (20.71)	14.52 (9.33)	1.49 (2.03)	2.18 (2.09)	0.23 (0.36)	0.2 (0.36)
	RI	20.97 (6.40)	24.32 (10.42)	39.28 (12.76)	35.40 (12.96)	66.67 (12.17)	67.03 (20.21)	64.84 (21.82)	52.27 (9.83)	81.77 (13.47)	72.63 (16.79)	48.84 (25.15)	49.82 (24.74)
C.C	*GI*	0.53 (0.51)	1.61 (1.22)	1.16 (0.84)	12.57 (4.71)	13.92 (4.39)	9.31 (6.43)	8.79 (6.35)	0.33 (0.52)	0.73 (0.94)	0.81 (0.86)	1.86 (1.79)	1.24 (1.16)
	RI	56.81 (20.32)	51.44 (14.36)	40.48 (15.29)	49.54 (13.54)	49.78 (14.55)	38.55 (13.10)	35.85 (8.67)	31.47 (20.95)	76.56 (14.13)	73.47 (18.46)	73.96 (16.98)	59.11 (11.35)
AF	*GI*	1.05 (1 .33)	1.54 (1.3)1	6.30 (4.40)	4.69 (3.38)	10.75 (3.41)	9.82 (5.67)	10.61 (4.30)	0.22 (0.52)	0.39 (0.55)	1.47 (2.89)	1.5 (1.32)	1.55 (1.19)
	RI	80.47 (19.66)	97.67 (21.26)	67.17 (16 .12)	65.33 27.69	61.46 (14.36)	42.12 (15.24)	51.63 (19.27)	22.55 (6.22)	68.59 (20.60)	63.31 (20.65)	68.55 (19.02)	61.26 (12.77)

Table 2. Monthly mean evolution of physiological index of *Holothuria tubulosa* in the study area. MAD: La Madrague. CC: Cap Carbon. AF: Ain Franin. Expressed % ± (standard deviation).

It can be noted that the highest average index of repletion is recorded at Ain Franin where the environment is rich in flora and fauna and with the presence of *Posidonia oceanica* meadows. This site is influenced by sporadic pollution, while the Cap Carbon site is under the influence of industrial pollution (Chahrour et al., 2013). The site of La Madrague presents a stony substrate with some clumps of *Posidonia* K.D. Koenig and it is under the influence of an agricultural pollution (Benghali et al., 2006).

The monthly variations of average gonad index are summarized in figure 3. For Cap Carbon and Ain Franin sites, respectively, the minimum values of 0.33± 0.52 % and 0.22± 0.52 % were recorded in September, while maximum values of 13.92 ±4.39 % and 10.75± 3.41 % in June. On the other hand, for the La Madrague site, the average gonad index minimum value of 0.2±0.36 % is registred in January and the maximum value is 22.85±20.71 % in August.

The maximum values of the gonad index were recorded in June and August, while during the winter season it is slowly decreasing. This decrease in GIm means (see Figs. 2, 3) that the gonad development is in pre-reproduction or spawning (Tanaka, 1958; Spirlet et al., 2000). These declines in GIm denote the existence of an autumn season spawning (September and October), as shown in figure 3.

The statistical study by ANOVA test shows no significant differences between GIm and the three sites (df=2; F=0.62; P>0.05) in contrast to the monthly and seasonal variation, GI has a significant difference (df=11; F=5.02; P<0.05) (df=3; F=18.59; P<0.05). Whereas for the RI, the difference is insignificant compared to sites, months and seasons. In this study, the microscopic observations confirm the spawning period of the population at the three sites. The tubules of the females and the males almost resorbed especially in the cold months as has been observed by Conand (1993a). In the hot months the gonads are more mature and prepare to spawn. This behavior was also reported by Navarro et al. (2012).

The females and males gonads are composed of 4 stages of maturity in the whole of the year.

Figures 4–9 shows the microscopic and macroscopic observations of female gonads of *H. tubulosa.* Stage I (recovery stage), in this case, it was not observed.

Stage II. Growing (Figs. 4, 5): tubule with early-vitellogenic oocytes and thick tubule walls.

Stage III. Mature (Fig. 6): tubule with mid-vitellognic oocytes.

Stage IV. Partly spawned (Figs. 7, 8): tubule with vitellogenic mature oocytes. The mature oocytes with a nucleus, germinal vesicle and follicular epithelium.

Stage V. Spent (Fig. 9): spawned tubule with the presence of relict oocytes and with pointed tubule end.

The microscopic observations of male gonads of *H tubulosa* are depicted in figures 10–15. Stage I (recovery stage), in this case, it was not observed.

Stage II. Growing (Figs. 10, 11): thick tubule with spermatozoa and growing tubule longitudinal fold.

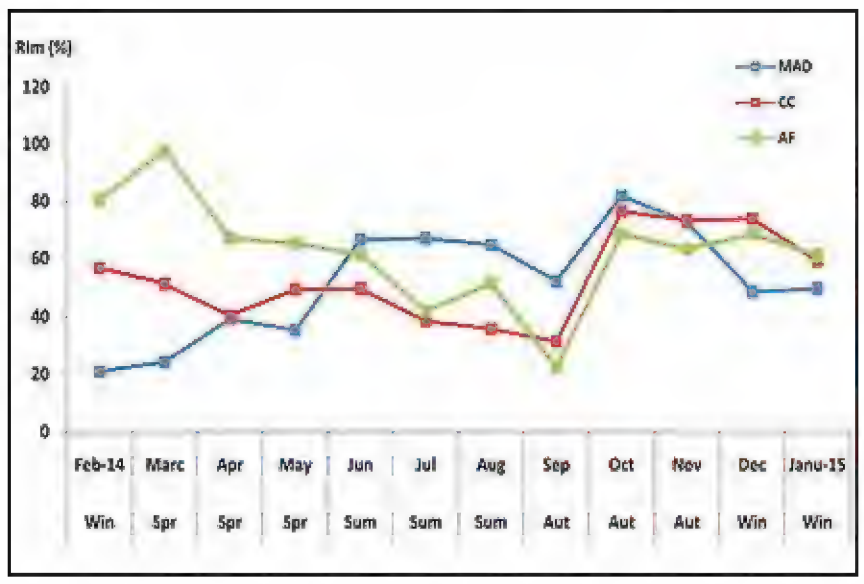


Figure 2. Monthly mean evolution of repletion index *Holothuria tubulosa* in the area. MAD: La Madrague. CC: Ca Carbon. AF: Ain Franin.

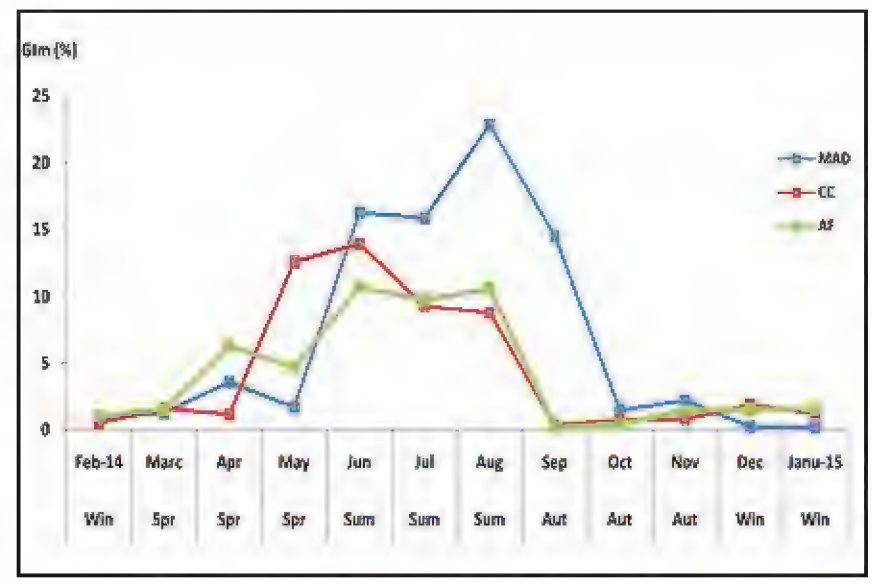
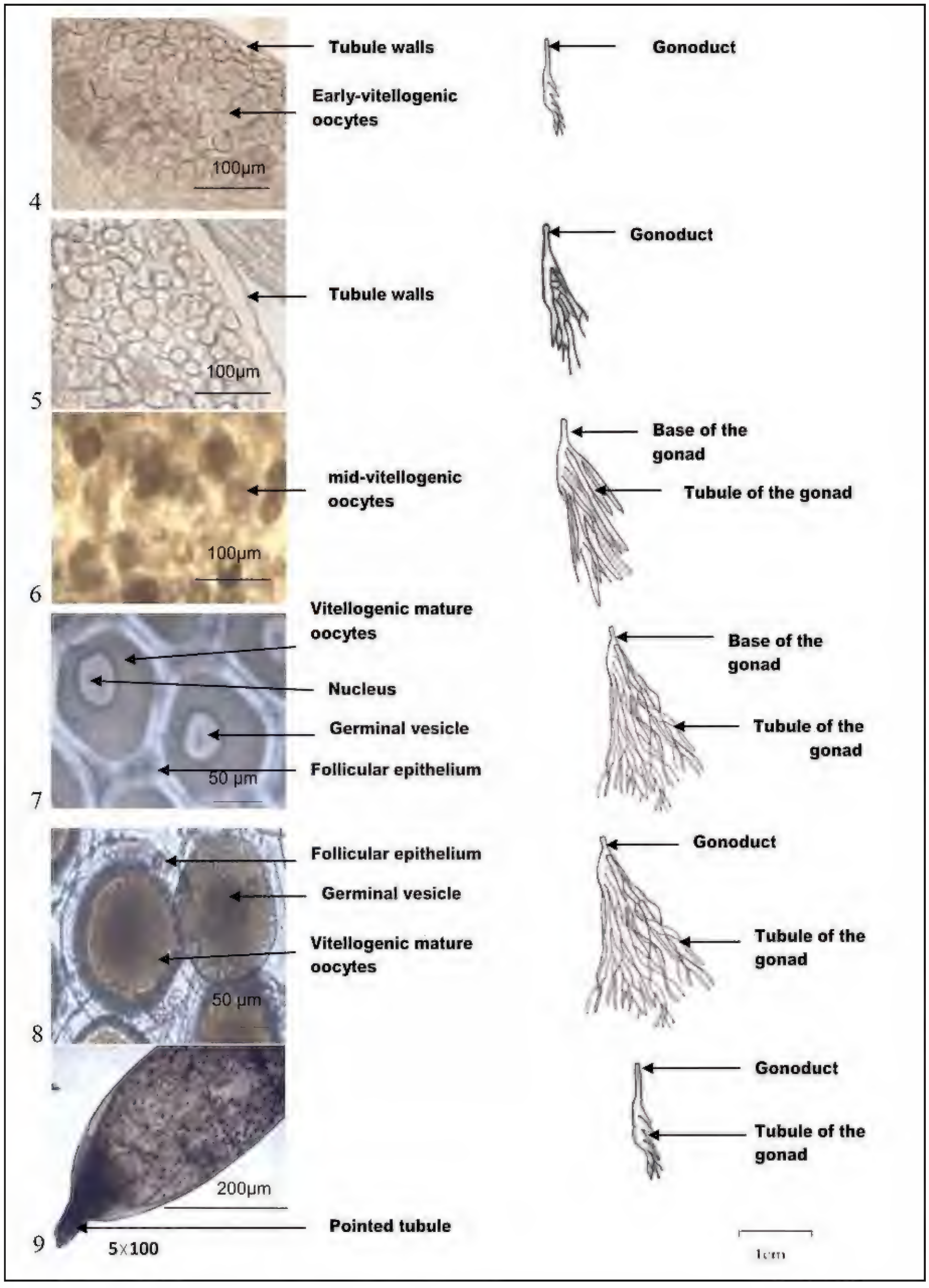
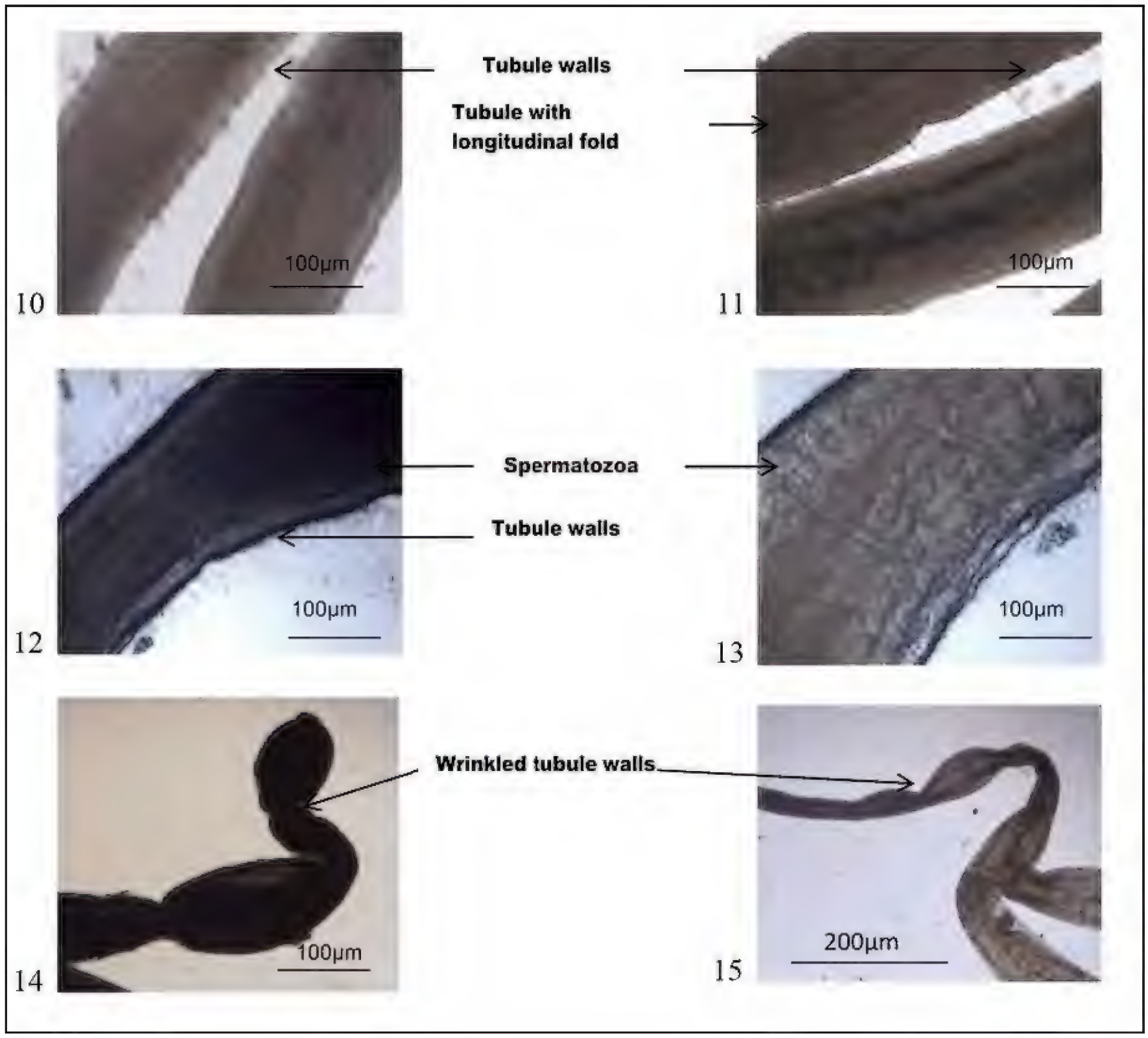


Figure 3. Monthly mean evolution of gonad index of *Holothuria tubulosa* in the area. MAD: La Madrague. CC: Cap Carbon. AF: Ain Franin.



Figures 4–9. Microscopic and macroscopic observations of female gonads of *Holothuria tubulosa*.



Figures 10–15. Microscopic observations of male gonads of *Holothuria tubulosa.*

Stage III. Mature (Figs. 12, 13): tubule with complete spermatozoa.

Stage IV. Partly spawned (Fig. 14): tubule with wrinkled and partly spawned.

Stage V. Spent (Fig. 15): tubule with wrinkled wall and completely spent.

Figures 16–24 show the effect of environmental conditions on gonad index and repletion index, where it can be seen that the temperature is the most important factor in the reproduction and feeding. For the three sites, the spawning period is between September and October where the temperature is around 19–20 °C. For the repletion index, the highest means are in the autumn season for two sites (La Madrague and Cap Carbon). For Ain Franin, on the other hand, it is during the spring season.

According to Spirlet et al. (2000) and Shpigel et al. (2004), an increase in temperature may increase ingestion and absorption efficiency and stimulate the growth and biological activities of sea cucumbers. In the autumn season, *H. hawaiiensis* Fisher, 1907 ingests more sediments than during the rest of the year to allow the growth of his sexual organs and the expulsion of gametes (Dar & Ahmad, 2006). Also the previous results confirm that the temperature is the most important factor affecting

the reproduction of *H. tubulosa* (Navarro et al., 2012; Dereli et al., 2016; Bahiri et al., 2017).

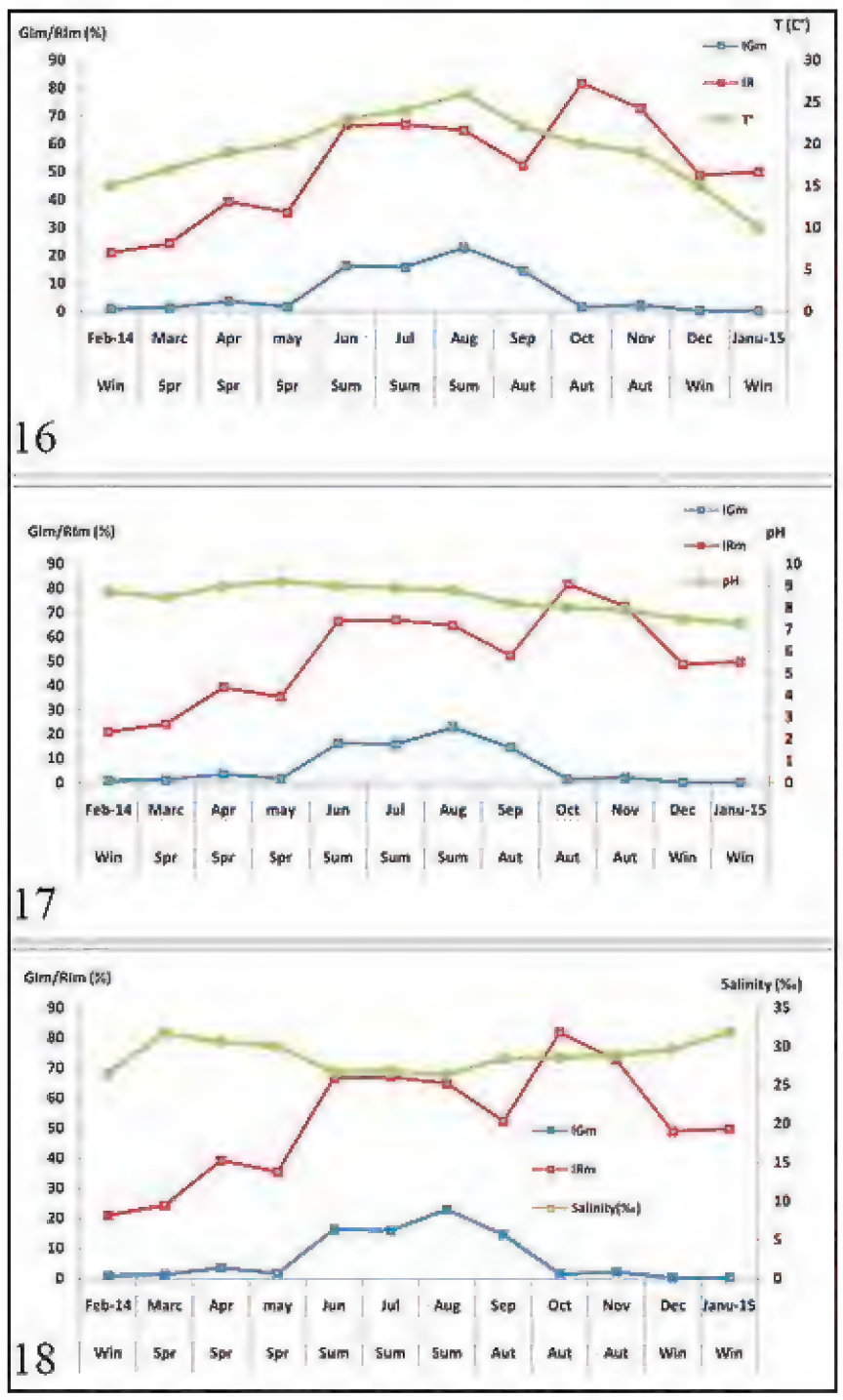
The average physical seawater parameters of the three sampling sites in Oran coast are summarized in Table 3.

There is no significant difference between the stations, the temperature, and pH. However, there is a significant difference between salinity and the study sites.

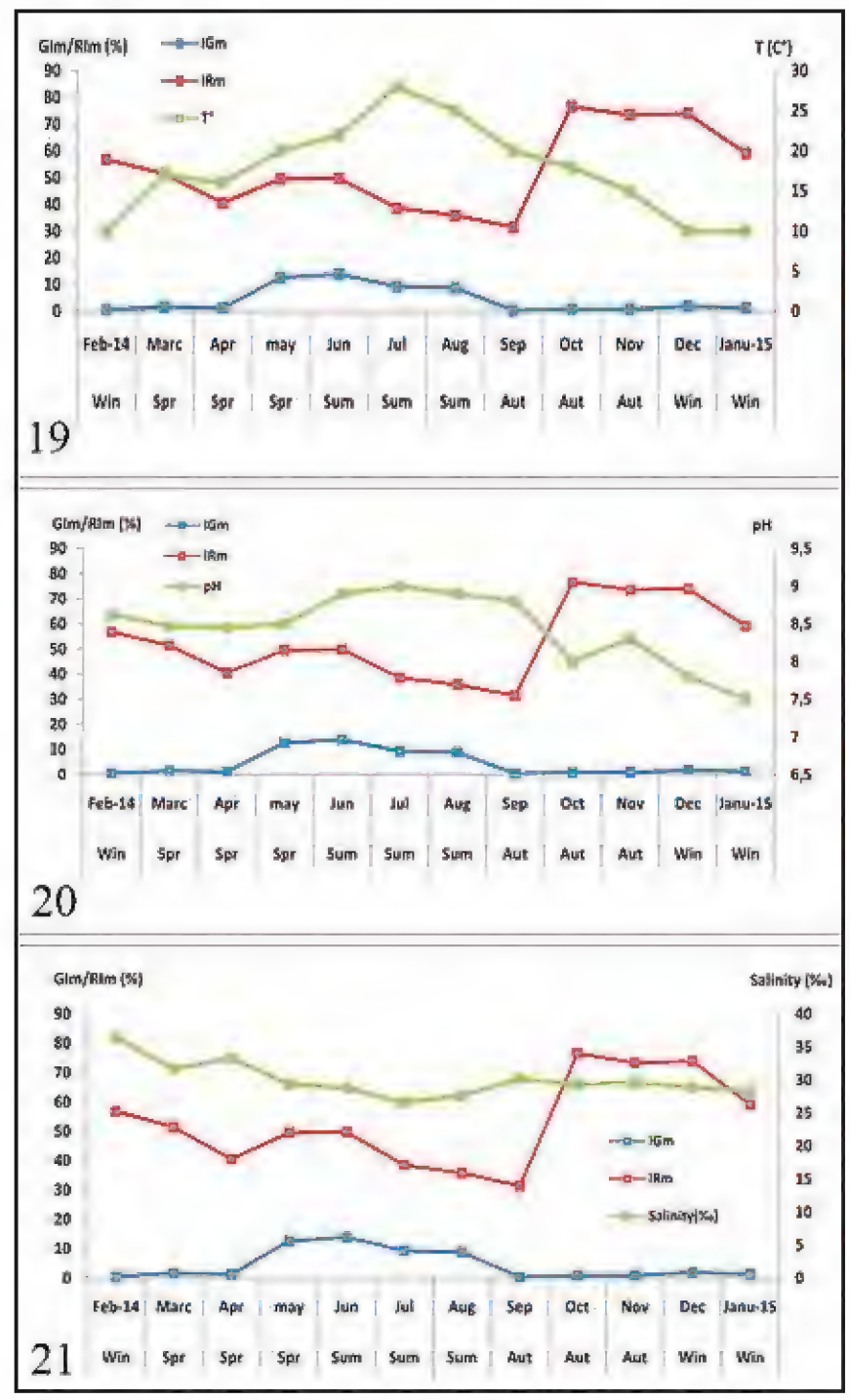
The temperature has a positive relationship with gonad index ($p<0.01$) as shown by the Pearson correlation analysis, presented in Table 4, and no correlation between temperature and index repletion. The pH has a positive correlation with gonad index ($p<0.05$) and also has a positive relationship with the temperature ($p<0.01$).

DISCUSSION

The sex ratio obtained from *H. tubulosa* in this study shows a significant difference in the relationship 1:1. In most sea cucumbers of the Aspidochirotida order the sex ratio usually coincides with a balanced relationship 1:1 (Ramofafia et al., 2001; Rasolofonirina et al., 2005; Asha & Muthiah, 2008). Despite some species show a slightly unbalanced ratio, with more males than females, or vice versa (McPherson, 1965; Navarro et al., 2012), some sea cucumber species have an unbalanced ratio of 1:2 or 2:3 due to fishing pressure affecting the population (Shiell & Uthicke, 2006; Muthiga et al., 2009). In Algeria, sea cucumbers are not exploited, thus it is assumed that



Figures 16–18. Monthly mean gonad index and repletion index of *Holothuria tubulosa* at La Madrague. Mean seawater temperature (Fig. 16), pH (Fig. 17) and salinity (Fig. 18).

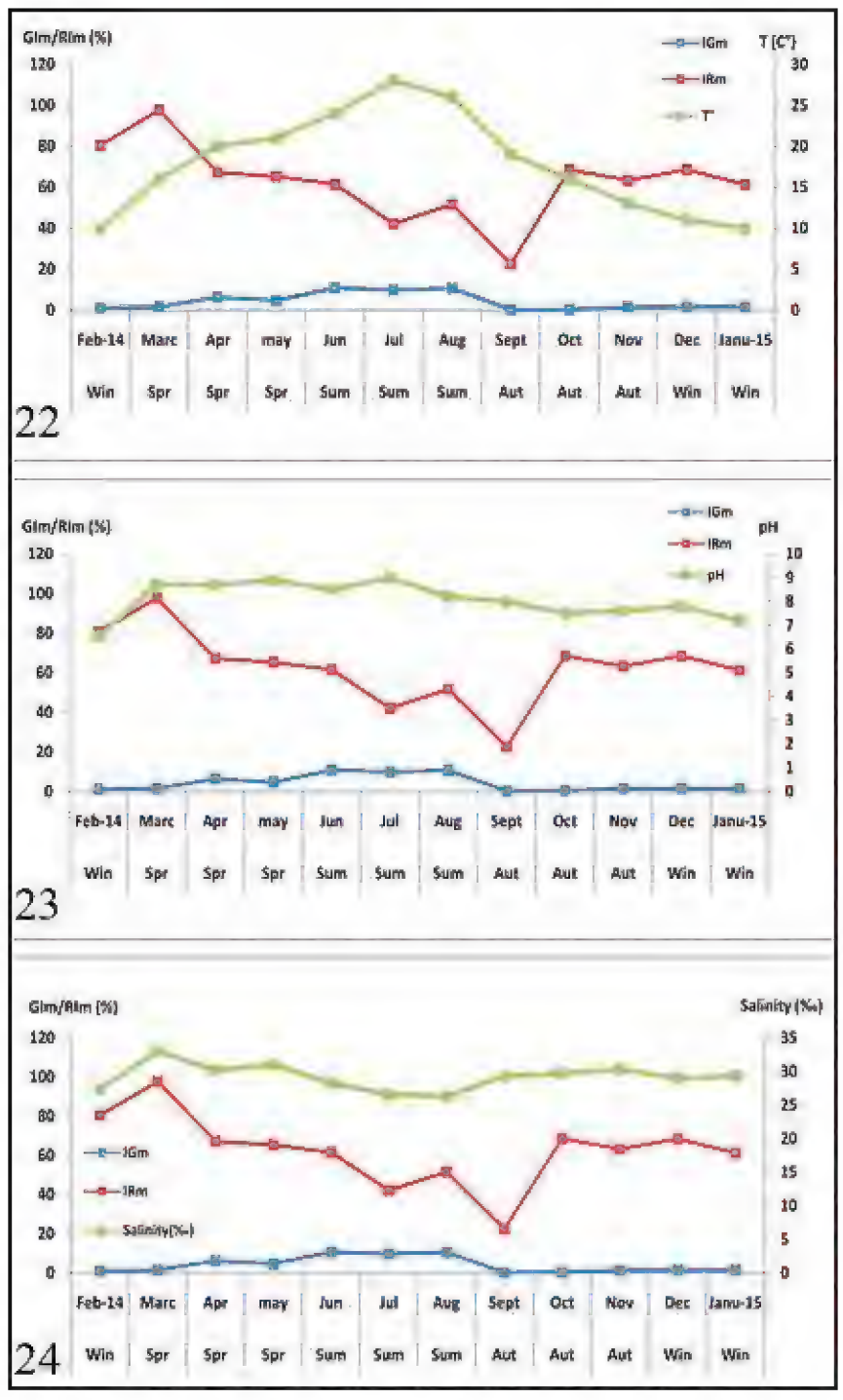


Figures 19–21. Monthly mean gonad index and repletion index of *Holothuria tubulosa* at Cap Carbon. Mean seawater temperature (Fig. 19), pH (Fig. 20) and salinity (Fig. 21).

there is another important factor that affects the balance of the sex ratio. This sex ratio unbalance can be explained by the pollution or the hydrodynamics which often favors the reduction of the populations as a response to stress.

In a population of *H. tubulosa*, the determination of the fluctuations of the digestive contents weight and the gonads is an essential approach to the trophic and spawning study of this marine invertebrate. It allows, primarily, to determine the structure and the evolution of benthic phytocenosis (Nedelec, 1982; Verlaque & Nedelec, 1983a, b) and secondly to clarify the gonadal activity.

The average repletion index shows maximum values in October and March and minimum values in September and February. Dar & Ahmad (2006) observed that *H. atra* Jaeger, 1833 in the Red Sea has the highest average weight and the lowest average percentage of sediments in spring. They concluded that at this time of the year the most individuals are at the stag, which precedes the maturation and are preparing for the period of reproduction, from June to July. They also observed (Dar & Ahmad, 2006) that the highest mean sediment weights were recorded in summer when individuals need sediments to contract and expel their gametes.


Glm/Rlm (%)
T (C°)
IGm
IRm
T
Feb-14 Marc Apr may Jun Jul Aug Sept Oct Nov Dec Janu-15
Win Spr Spr Spr Sum Sum Sum Aut Aut Aut Win Win
22
Glm/Rlm (%)
pH
IGm
IRm
pH
Feb-14 Marc Apr may Jun Jul Aug Sept Oct Nov Dec Janu-15
Win Spr Spr Spr Sum Sum Sum Aut Aut Aut Win Win
23
Glm/Rlm (%)
Salinity (‰)
IGm
IRm
Salinity(‰)
Feb-14 Marc Apr may Jun Jul Aug Sept Oct Nov Dec Janu-15
Win Spr Spr Spr Sum Sum Sum Aut Aut Aut Win Win
24

Figures 22–24. Monthly mean gonad index and repletion index of *Holothuria tubulosa* at Ain Franin. Mean seawater temperature (Fig. 22), pH (Fig. 23) and salinity (Fig. 24).

Feeding behavior and feeding mechanism of sea cucumbers during the different seasons are related to the stage of sexual maturation of the animal (Dar & Ahmad, 2006). The sea cucumbers often show an annual cycle of reproduction as observed by other studies (Navarro et al., 2012; Mezali et al., 2014; Dereli et al., 2016).

The study shows that GIm values increased during the year, and the spawning peak is registered when the GI values are low in October for the La Madrague site and in September for the other two sites (Ain Franin and Cap Carbon), while GI values have their maximum between June and August. The field observations show and confirm that spawning occurs in shallow waters during the summer in the Mediterranean populations (Valls, 2004; Moosleitner, 2006; Andrade et al., 2008). The results of our study coincide with those of the work performed in the regions of the Dardanelles Strait (Dereli et al., 2016) and of the Aegean Sea (Kazanidis et al., 2010; Kazanidis et al., 2014) and other regions (Despalatović et al., 2004; Navarro et al., 2012) (see Table 5 with *H. forskali* Delle Chiaje, 1823 and *H. sanctori* Delle Chiaje, 1824).

For many species of echinoderms, the spawning is extended over a long period, but the reproduction season can be shortened when the environmental conditions are not favorable for a short period (Giese, 1987; Chia & Walker, 1991; Pearse & Cameron, 1991).

The correlation was observed between GIm of *Holothuria tubulosa* and the sea water temperature of the Oran coast. This result confirms previous studies that claim that the temperature is the most important factor affecting reproduction of *H. tubulosa* (Despalatović et al., 2004; Kazanidis et al., 2010) and other congeneric species (Conand, 1981; Tuwo & Conand, 1992; Despalatović et al., 2003).

The seasonal variations of seawater temperature and photoperiod are common parameters correlated

Area	T°(C)	pH	Salinity (‰)*
La Madrague	19.16±4.26	8.42±0.66	28.85±1.89[a]
Cap Carbon	17.58±5.85	8.44±0.45	30.03±2.56[b]
Ain Franin	17.83±5.94	8.05±0.73	29.22±1.83[a]

Table 3. The comparison of physical parameters at stations in Oran coast (mean ± standard deviation). *: Significant difference between salinity and sites (Madrague and Cap Carbon. $p<0.05$; Cap Carbon and Ain Franin. $p<0.05$).

with reproductive synchrony (Boolootian, 1966; Giese & Pearse, 1974). Although, some echinoderms appear to show more prolonged or continuous spawning throughout the year in tropical climate regions (Harriott, 1985).

In literature, some studies show the existence of a close relationship between temperature and reproduction of *Actinopyga mauritiana* (Quoy & Gaimard, 1834) in the island of Guam (Conand & Sloan, 1989; Conand, 1993a, b). In fact, in the Mediterranean Sea, another study suggests that the spawning would be induced when the water temperature is between 13–20 °C (Fenaux, 1980). In our study, it is clear that the beginning of spawning depends on the sea temperature in the populations of the three sites (Figs. 4a, 5a, 6a). The starting point of the spawning of this echinoderm is much more induced by the sudden increase of sea temperature due to salinity and pH. There are other factors favoring the induction gametic, such as turbulence (Pedrotti, 1993; Soualili, 2008), the phytoplankton blooms (Pedrotti, 1993; Starr et al., 1993), the hydrodynamics (Soualili, 2008; Dermeche, 2010; Navarro et al., 2012) and the photoperiod (Starr et al., 1993; Spirlet et al., 1998).

The effect of sea temperature and light variations on sea cucumber feeding activity is not extensively documented in the literature. Coulon & Jangoux (1993b) estimated that a sea cucumber population can filter from 6 to 13 kg of sediments according to temperature and body size. Due to this activity, the sea cucumbers alter the stability of the seabed (Massin, 1982; Coulon & Jangoux, 1993b; Dar & Ahmad, 2006).

CONCLUSIONS

In this study, it has been able to estimate and evaluate the spawning period of *H. tubulosa.* The sex ratio was found as (female: male) 0.8:1.2 with no significative difference between sites and seasons (spring, summer, autumn, winter). The spawning period was between September and October in the west coast of Oran. The peak spawning is reg-

	T°(C)	pH	Salinity (‰)	GI	RI	station	Months
pH	0.569**						
Salinity (‰)	0.015	0.176					
GI	0.712**	0.370*	-0.131				
RI	-0.232	-0.242	-0.220	0.018			
Station	-0.101	-0.194	0.027	-0.173	0.243		
Months	-0.224	-0.339*	-0.148	-0.137	0.206	0.000	
Seasons	0.563**	0.195	0.057	0.246	0.053	0.000	0.194

Table 4. Correlation between physical parameters of areas, physiological index (GI, RI), months and seasons.
*: significantly different ($p < 0.05$). **: significantly different ($p < 0.01$).

istered where the values of GI are low in October for the La Madrague site with values of 1.49±2.03 %, and in September for the other two sites of Cap Carbon and Ain Franin, with values of 0.33± 0.52 % and 0.22± 0.52 % respectively, while the GI values have their maximum between June and August. The temperature of seawater seems to play a crucial role in the release of gametes.

Other studies are also needed on this coast and generally in all the Algerian coasts in order to obtain more information (density, mortality, and longevity).

Species	Location	Methods	Reproductive pattern	Spawning period	Reference
H. tubulosa	Oran coast, Algeria	GI	Annual	Sept-Oct	Ower study
H. tubulosa	Oran coast, Algeria	GI	Annual	Mar- Apr- Jul and Oct	Bahiri et al., 2017
H. tubulosa	Dardanelles Strait, Turkey	GI	Annual	August and September	Derlie et al., 2016
H. tubulosa	Pagasitikos Gulf, western Aegean Sea, Greece	Histological examination	Annual	Summer	Kaznidis et al., 2014
H. tubulosa	Adriatic Sea, Croatia	Histological examination	Annual	Jul- sept	Despalatovic et al., 2004
H. tubulosa	Costa Brava,the north east coast of Spain	Field spawning observation		June and July	Valls, 2004
H. tubulosa	Ischia Island, Italy	Field spawning observation	Annual	August-sept	Bulteel et al., 1992
H. forskali	Britain	Histological examination and GI	Annual	Apr- June	Tuow & Conand, 1992
H. forskali	Adriatic Sea	Histological examination	Annual	Jun-August and Dec	Despalatovic et al., 2003
H. sanctori	Gran Canaria, Spain	GI, macro and microscopic analysis of the physical characteristics of tubules.	annual	Jun-August	Navarro et al., 2012

Table 5. Characteristics of Holothurian species reproduction. Location, methods used and spawning period.

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It is highly recommended all appropriate datasets, images, and information to be deposited in public resources. Please provide the relevant accession numbers (and version numbers, if appropriate). Accession numbers should be provided in parentheses after the entity on first use. Examples of such databases include, but are not limited to: Zoobank (www.zoobank.org), Morphbank (www.morphbank.net), Genbank (www.ncbi.nlm.nih.gov/Genbank), BarCode (Www.barcodinglife.org).

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